RELATIONSHIPS BETWEEN AQUATIC BIRDS AND WETLAND CHARACTERISTICS IN THE ASPEN PARKLAND, CENTRAL BRITISH COLUMBIA

W. Sean Boyd
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ABSTRACT

We assessed the significance of a number of wetland habitat components to aquatic birds in the Aspen Parkland of central British Columbia. Through correlation, principal component, and linear regression analyses, we found wetland size (**Area of Open Water**) to be consistently the most important abiotic variable for both adult (potential breeders) and brood counts. Wetland size was included in almost all species regression equations and, because it explained most of the variance in counts, it was generally entered first. Other significant, positively correlated variables were: **Mean Depth, Area of Snags, Conductivity,** and **pH.** With minor exceptions, we found low correlations between aquatic birds and biotic variables (aquatic plants and invertebrates). The features measured explained a greater amount of the variance in potential breeder abundance than in brood abundance.

The dominance of wetland size, if biologically meaningful, suggests that some spacing mechanism might be responsible for distributing the birds throughout the wetlands, independent of wetland characteristics. However, because several variables (**Mean Depth, Conductivity,** and **pH**) were positively associated with wetland size, it is possible that their contributions were over-shadowed in the regression analyses. Another possible reason for the overriding effect of wetland size might be that species were using the study area as a complex, and they therefore were not selecting specific wetlands for specific features. We recommend that future studies on aquatic bird/habitat relationships use an experimental approach in which wetland size is held constant and bird/habitat surveys are conducted within complexes but across different biogeoclimatic zones.

RESUME

Nous avons essayé de déterminer l'importance de plusieurs composantes de l'habitat pour les oiseaux aquatiques de la forêt ouverte du centre de la Colombie Britannique. Avec l'aide d'analyses de corrélation, de composantes principales et de régression multilinéaires, nous avons trouvé que la superficie de l'étang (surface d'eau ouverte) était la variable abiotique la plus importante pour les canards adultes (nicheurs potentiels) et pour les couvées. La superficie de l'étang entra dans la formule de regression de presque toutes les espèces et, comme elle expliquait la plupart de la variance, était souvent entrée la première. Les variables suivantes étaient aussi associées de façon positive à la densité d'oiseaux aquatiques: la profondeur moyenne de l'étang, l'abondance d'arbres morts, la conductivité de l'eau, et le pH. Les correlations entre les oiseaux aquatiques et les variables biotiques (plantes aquatiques et invertébrés) étaient généralement faibles sauf quelques exceptions. Les variables mesurées expliqueraient une proportion plus grande de la variabilité dans le nombre de nicheurs potentiels que dans le nombre de couvées. Si la dominance de la superficie de l'étang sur les autres variables mesurées est biologiquement significa tive la distribution des oiseaux dans la région étudiée serait plus influencée par les méchanismes de dispersion des oiseaux que par les caractéristiques de l'étang. Cependant, puisque plusieurs variables telles la profondeur moyenne, la conductivité et le pH étaient associées positivement avec la superficie de l'étang, il est possible que leur importance ait été masquée dans les analyses de régression. Il est aussi possible que les oiseaux aient utilisé la région d'étude comme un complexe d'étangs sans nécessairement répondre aux caractéristiques individuelles des étangs. Nous recommendons que les études ultérieures sur les relations entre oiseaux aquatiques et leur habitat,

1) utilisent une approche plus expérimentale où la dimension de l'étang serait tenue constante et 2) comparent des complexes d'étangs dans plusieurs zones biogéographiques, afin d'obtenir une plus grande variabilité dans les variables mesurées.

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1. INTRODUCTION

Riske Creek is the centre of one of the most important wetland complexes for breeding waterfowl in British Columbia (McKelvey and Munro 1983). To protect and manage that complex and others for the benefit of aquatic bird populations, an understanding of the relationships between habitat and bird numbers is needed; that is, specific wetland abiotic and biotic factors responsible for attracting and ultimately influencing the breeding success of different species.

Recent years have seen some progress in our understanding of those relationships (Patterson 1976; Danell and Sjoberg 1978; Nilsson and Nilsson 1978; Mack and Flake 1980; Godin and Joyner 1981; Talent et al. 1982; Mulhern et al. 1985). Most studies dealt with dabbling duck species (specifically Mallard (Anas platyrhynchos) and Blue-winged Teal (A. discors)) using prairie potholes. Some of those studies found that a few habitat variables could explain a considerable amount of the variation in bird numbers. The same study approach has not been applied to other species of aquatic birds such as diving ducks and grebes, however.

The primary objectives of our study were to identify potentially important abiotic habitat components of Riske Creek wetlands and to determine the amount of variation in adult and brood numbers of different aquatic bird species and species groups that could be accounted for by those components. A secondary objective was to determine the significance of biotic habitat components. Such information could be useful in the development of habitat evaluation models for assessment, acquisition, and management purposes (Larson 1976; Reppert et al. 1979; Adamus 1983). It might also help in predicting population levels of selected species or species groups and in identifying, on a broad scale, associations worth studying by more intensive, experimental means.

All data collected during this study are available in Canadian Wildlife Service reports (Boyd and Savard 1987; Boyd and Smith 1989).

2. STUDY AREA

Our study area is located in the Aspen Parkland of south-central British Columbia on the Fraser Plateau about 40 km west of Williams Lake (Figures 1 through 5). The Riske Creek area was chosen because of its importance to breeding waterfowl (Canada Land Inventory Class 1 status) and because it was the focus of an intensive, long-term waterfowl survey by the Canadian Wildlife Service. Our study area included 118 wetlands distributed over 200 km^2 across two biogeoclimatic subzones of the Interior Douglas Fir zone (Annas and Coupe 1979).

The Fraser Plateau is flat to rolling country between 900 and 1500 m above sea level. It is comprised of deformed Paleozoic and Mesozoic sedimentary rocks partially overlaid by flat volcanic flows (Holland 1976). The bedrock is covered by a blanket of till deposited during pleistocene glaciation (Tipper 1971). The soils are calcareous in nature and have a high base status.

In general, the wetlands at Riske Creek are relatively shallow and small (Table 1) with narrow strips of emergent and submergent plant associations around their edges. Because of a moderately dry climate, volcanic derived parent materials, and rolling topography, salts accumulate to varying degrees and water levels tend to fluctuate over the short and long-term causing the development of snag (dead tree) zones.

Based on a wetland classification system developed for the Cariboo Region of British Columbia (Runka and Lewis 1981), our wetlands have palustrine or lacustrine hydrotopographic characters. The predominant classes are shallow

open water, marsh, and meadow. Only a few wetlands have associated fen, shrub-carr, or swamp classes. The shallow open water subclasses range from fresh to moderately saline, the marsh subclasses are shallow and deep, and the meadow subclass is mainly mineral. Based on the latest wetland classification system developed for the United States (Cowardin et al. 1979), our wetlands have lacustrine and palustrine systems. The limnetic and littoral subsystems for the lacustrine systems have primarily unconsolidated bottom and aquatic bed classes. The main classes for the palustrine systems are unconsolidated bottom, aquatic bed, and emergent. The wetlands are typically oligosaline and alkaline, however salinities range from fresh to mesosaline and a few wetlands have pHs that are close to neutral (Table 1).

3. DATA COLLECTION

3.1 Bird Data

We conducted 24 spring surveys of aquatic birds over 5 years (1980-1984) from late April to late May. We counted adult males, females, and subadults (all termed "adults" in this report) of all species on each wetland. Observations were made at 1 to 3 points along the perimeter of each wetland using binoculars or a spotting scope. Numbers for each species for each wetland were totalled over the 5 years. Those numbers were also converted to mean counts per survey when we adjusted for migrants (discussed below).

We conducted a minimum of 4 waterfowl brood surveys during June and July in each of the same 5 years using the same techniques. Brood counts were not conducted for the grebe species and American Coot (Fulica americana). We aged broods by plumage growth using a combination of the criteria developed by Gollop and Marshall (1954) and Taber (1971). Numbers for each species for each wetland were totalled over the 5 years. The maximum number of broods seen for each species for each wetland over the 5 years was also tabulated.

We used 5 year totals (and mean values) for adults and broods in our analysis, rather than separate annual counts, in order to minimize the variability known to occur in bird surveys through natural causes (climate, predation, etc.) and sampling error. We considered maximum brood counts in addition to total brood counts because we felt that the former was a better estimate of a wetland's carrying capacity for a given species in terms of the number of broods that could be supported.

3.2 Habitat Data

Abiotic Environment

We surveyed and made rough field maps of each wetland in June and July 1983. Color air photos (scale 1:5000), taken in September 1983, were used to map each wetland by enlarging their negatives to a scale of 1:1500. An Apple II+ computer and graphics tablet were used to calculate areas of each plant association and lengths of edges between.

We determined depth profiles for all wetlands during June and July 1983. That year was average for precipitation at Riske Creek (Atmospheric Environment Service, Environment Canada, unpubl. data) and surface waters were at or close to shallow marsh/wet meadow or upland interfaces throughout the study area and period of measurement. Therefore, water levels were considered to be close to the long-term mean ($\pm$ 0.1 m). A measured rope with weight attached was used to determine depths from a canoe along grids or transects to/from prominent shoreline features. Field data were transferred to the 1:1500 scale maps and areas for all contour intervals were determined using the graphics tablet.

Water samples were collected from all wetlands at 3 different times: July 1982, June 1983, and August 1983. Samples were collected at waist depth by emersing plastic bottles 10 cm under the surface. Analysis took place at our

field lab within 48 hours. We determined conductivity and salinity using a S-C-T Meter (Yellow Springs Instrument Co.) and calcium, sodium, and pH using a Specific Ion Meter (Orion Research Inc.). In September 1984, we sampled 92 of the above wetlands in the same manner. The samples, collected in sterilized bottles, were shipped on ice to Inland Waters Directorate (Environment Canada, North Vancouver, B.C.) where they were analyzed for the following parameters using standard methods: phenol alkalinity, total alkalinity, hardness, magnesium, chloride, sulphate, nitrate nitrogen, total dissolved nitrogen, total phosphorus, and turbidity.

Biotic Environment

In addition to the abiotic data described above, we also collected aquatic plant and invertebrate data. Aquatic plants were surveyed by canoe in June and July, 1983. Physical dimensions of plant associations were outlined on rough field maps. All species were identified using Hitchcock and Cronquist (1973) and we estimated their cover-abundance values using the Braun-Blanquet scale (Mueller-Dombois and Ellenberg 1974). The associations were mapped with the help of field notes, contour data, and air photos. The total area occupied by each species in each wetland was then calculated using the mean value of each Braun-Blanquet interval.

We sampled aquatic invertebrates from a subset of wetlands using activity traps, bottom corers, and sweep nets. Wetlands were first stratified by water chemistry (pH, conductivity, and calcium) and waterfowl use. Forty-three wetlands were sampled using the sweep net technique in June and July of 1984 and 1985, the same wetlands were sampled by bottom corer in 1985, and only 8 of those wetlands were sampled by the activity trap technique in 1985. Most of the sampling was performed at regular intervals around the shoreline of each wetland at 0.5 and 1.0 m depths. Numbers for selected major taxa were

converted to dry weights using conversion factors calculated for wetlands at 100 Mile House (G. Gauthier, unpubl. data).

For a more complete description of the above methods and their results, see Boyd and Savard (1987) and Boyd and Smith (1989).

4. DATA ANALYSIS

4.1 Abiotic Environment

Dependent and Independent Variables

Dependent variables were grouped into 2 classes: adult counts and brood counts. Independent abiotic variables were grouped into 3 classes: bottom contour areas, morphometric variables, and water chemistry variables. The "extra" water chemistry variables, measured only once for 92 wetlands, were considered to be less reliable than the averaged measurements for pH, conductivity, calcium, etc. determined over 112 wetlands. We therefore performed our analysis twice, once excluding those extra variables and once including them, to determine the magnitude and direction of their effects.

We used only 21 of the 24 spring adult surveys in our analysis. Freezing conditions during 3 late April surveys forced all birds to concentrate on only a few ice-free wetlands (Table 2). Those 3 surveys were therefore considered inappropriate for studying habitat selection. Also, because the spring surveys included migrants, we reconstructed the data set so that it contained only potentially breeding adults. For each species, we used only those surveys which covered the period after the departure of migrants when the breeding population was stable. Because species have different breeding chronologies, the dates and number of surveys that could be used varied from species to species. Thus, we converted total counts to mean counts per survey.

Transforming the Data

To determine the distribution of the data, we produced frequency histograms for all bird and habitat variables using SPSS:X (SPSS Inc., 1986). All variables except pH were significantly skewed to the right so they were transformed using log(x+1). That helped correct for heteroscedasticity and non-normality (Sokal and Rohlf 1969; Zar 1974).

Treatment of Wetland Outliers

Six wetlands did not follow the patterns of the others in bivariate plots among variables. Two of those (#83 and #117) were irregularly surveyed, were the largest and deepest, and were the only wetlands with fish populations. The other 4 wetlands (#103, #105, #108, and #116) were the smallest and shallowest and often dried up during the study period. Those 6 wetlands were considered to be extreme cases and were therefore excluded from further analysis. Thus, we used data from 112 of the 118 wetlands surveyed.

Habitat Data Reduction

Because of the great number of abiotic habitat variables considered and the many dependencies among them, it was necessary to reduce them to a manageable subset. We followed the recommendation of Kaminski and Prince (1984) that only 1 variable of an interrelated set should be analysed. To accomplish that, we subjected the 3 classes of abiotic habitat variables to cluster analysis using (Pearson) correlation as the measure of similarity. We selected variables that were both representative of separate clusters and easy to measure either with minimal field work or from satellite imagery or air photos. We checked the correlation matrix to ensure that no 2 variables had a correlation coefficient higher than 0.65. The variables resulting from the 3 cluster analyses were then merged into a single file. We avoided using

morphometric indices (relative depth, shoreline development, etc.) because they are functions of other variables. It would have been difficult to interpret their influence on bird counts.

Visual Representation and Prediction

We used a combined correlation analysis, principal component analysis (PCA), and multiple regression analysis (MRA) approach, as recommended by Kaminski and Prince (1984). Correlation analysis was used to describe general trends. PCA was used to visually illustrate the relationships among bird species abundance and selected habitat variables (SPSS Inc., 1986). We used stepwise MRA to delineate the most significant abiotic habitat variables and their predictive capabilities for adult and brood numbers. To minimize the chance of spurious, irrelevant variables entering regression equations, the probability of variable entry was set at 0.05 and entry was terminated when R^2 was not increased by more than 5% (Murphy et al. 1984). The significance of a variable was determined by the number of times it was entered into separate (species) regression equations and the number of times it was entered first. Predictive capability corresponded to the amount of variation in species counts explained.

4.2 Biotic Environment

A complementary but secondary objective of our study was to relate bird species to their biotic environment (i.e. aquatic invertebrates and aquatic plants). We used simple correlation analysis only. The intent was to follow the same analyses steps described for the abiotic variables only if significant associations were found.

5. RESULTS

5.1 Bird Data

Adults

Thirty species of aquatic birds (i.e. adults; migrants included) used the study area wetlands (Table 3). The most abundant species were Scaup sp. (*Athya sp.*), Barrow's Goldeneye (*Bucephala islandica*), and Bufflehead (*B. albeola*). They accounted for 21.6%, 16.5%, and 10.0% respectively of the total number of adult aquatic birds. The dominant dabbling ducks were American Wigeon (*Anas americana*) (7.6%) and Green-winged Teal (*A. crecca*) (4.9%). American Coot was also numerous (6.2%).

Table 4 and Figure 6 present the correlation matrix and PCA plot respectively for mean adult counts of the 21 species of aquatic birds, adjusted for migrants. The first 3 principal components accounted for 59.5% of the variation in species numbers. The dabblers and divers were distributed into 2 slightly overlapping groups.

The following sub-groups were apparent (Figure 6):

1. Mallard, Scaup sp., Barrow's Goldeneye, and Bufflehead.
2. Northern Pintail (*A. acuta*), Green-winged Teal, Northern Shoveler (*A. clypeata*), Gadwall (*A. strepera*), Blue-winged Teal and American Wigeon.
3. Redhead (*Aythya americana*), Canvasback (*A. valisineria*), and Ruddy Duck (*Oxyura jamaicensis*).
4. Canada Goose (*Branta canadensis*) and Red-necked Grebe (*Podiceps grisegena*)
5. Pied-billed Grebe (*Podilymbus podiceps*) and American Coot.

Eared Grebe (*Podiceps nigricollis*) was closely associated with sub-group 1 and Ring-necked Duck (*A. collaris*) was positioned near sub-group 3.

Broods

Sixteen species of waterfowl nested at Riske Creek (Table 5). Barrow's Goldeneye and Bufflehead accounted for most of the broods observed in the study area (22.3% and 17.8% respectively). Blue-winged Teal and Mallard were the dominant dabbling duck species with 11.0% and 9.5% respectively. Scaup sp. accounted for 21.6% of the adult population but only 5.2% of the broods; that resulted because they are late July/early August nesters (we consequently missed a large number of their broods) and because large numbers of migrating Scaup sp. were present during our spring surveys (Table 3).

The maximum number of broods described the waterfowl breeding population similarly (Table 6). The 2 brood counts (i.e. total and maximum) varied closely together over all wetlands for all species (average R=.944; Table 7). Because of that close association, only total brood counts were used in subsequent analysis.

Table 8 and Figure 7 present the correlation matrix and PCA plot respectively for total brood counts of the 16 waterfowl species. The first 3 principal components accounted for 48.4% of the variation in species numbers. Considerably more overlap existed between the dabbler and diver groups and the species were much more dispersed throughout the plot compared to that for the adults. Variation within groups was large, especially for the divers. Only 2 sub-groups were apparent:

1. Mallard, Barrow's Goldeneye, Bufflehead, and Ring-necked Duck.
2. Redhead, Canvasback, Ruddy Duck, and Scaup sp.

The remaining species were dispersed throughout the plot, showing various degrees of co-association.

5.2 Abiotic Environment Data

We divided the bottom contour variables into 3 clusters, corresponding to a correlation cutoff just below 0.6 (Table 9 and Figure 8). We chose the following to represent the range of bottom contours in our study area: **Area between 0 and 1 m**, **Area between 1 and 3 m**, and **Area between 3 and 5 m** (very few wetlands had maximum depths exceeding 5 m).

We merged the above 3 bottom contour area variables with other selected morphometric variables. A correlation cutoff just below 0.6 resulted in the following morphometric variables (Table 10 and Figure 9): **Mean Depth**, **Area of Open Water**, **Area of Marsh**, **Area of Snags**, and **Length Closed**. The 3 bottom contours were not selected.

We reduced the number of water chemistry variables by using a correlation cutoff just above 0.6 (Table 11 and Figure 10). **Conductivity**, **Calcium**, and **pH** were chosen as representative of the major clusters for 112 wetlands. We also selected the following as representative of other major clusters for 92 wetlands: **Nitrate Nitrogen**, **Total Dissolved Nitrogen**, **Total Phosphorus**, and **Turbidity**.

We merged the 5 morphometric variables with the selected water chemistry variables to develop 2 separate habitat (independent variable) files (Table 12). No large ($R>0.65$) associations remained (Tables 13 and 14).

5.3 Bird-Abiotic Environment Relations: Adults

The number of species for which a variable is correlated both significantly and positively is a measure of its overall importance. Aside from **Area of Open Water** (19 times out of 21 significant and positive), **Mean Depth** (11 of 21), **Area of Snags** (9 of 21), **Conductivity** (11 of 21), and **pH** (9 of 21) were clearly important wetland features (Table 15). In addition, none of those variables was correlated significantly and negatively with any

species. Therefore, based on the correlation matrix alone, the abundance of adult aquatic birds was associated with the larger, deeper wetlands having large snag communities, high conductivities, and high pHs.

In the PCA, the first 3 components accounted for 53.8% of the variation for the 21 aquatic bird species and 8 habitat variables (Figure 11). Dabbling ducks and diving ducks were distributed into 2 distinct groups. The dabblers had little association with any of the habitat variables, except for a moderate association between Mallard and **Area of Open Water**. The diving ducks, on the other hand, varied closely with **Area of Open Water** and somewhat less with **Mean Depth**, **Conductivity**, and **pH**. The grebe species, Canada Goose, and American Coot were distributed in a loose, detached group; they were associated with **Calcium**, **Area of Marsh**, **Length Closed**, and **Area of Snags** to varying degrees.

Area of Open Water was by far the most significant variable in the stepwise MRA (Table 16). It was entered into the regression equations for 16 of the 21 species and, for 14 of those 16, it was entered first. It was also the only variable entered into the regressions for Total Dabblers, Total Divers, and Total Birds. The remaining variables differed in significance but all were dominated by **Area of Open Water**.

Area of Open Water explained a considerable amount of the variation in the adult counts for Mallard (40%), Scaup sp. (42%), Barrow's Goldeneye (54%), Bufflehead (60%), Total Divers (70%), and Total Birds (69%). Other variables were more important in explaining variation in other species counts: **Area of Marsh** for Pied-billed Grebe (12%) and American Coot (21%), **Conductivity** for Northern Shoveler (19%), and **Mean Depth** for Horned Grebe. The remaining variables were of significantly less or no importance in explaining variation for any species.

The significant, positive associations apparent in the correlation matrix (Table 15) were masked in the regression analyses due to the moderately high correlations among the habitat variables (Table 13). Once **Area of Open Water** had been entered into an equation, other correlated variables were unable to explain significant amounts of the residual variance and were therefore ignored.

5.4 Bird-Abiotic Environment Relations: Broods

Aside from **Area of Open Water** (11 significant, positive correlations out of 16), **Mean Depth** (9 of 16), **Conductivity** (8 of 16), and **pH** (9 of 16) were important wetland features for the broods (Table 17). None had significant, negative correlations with any species. **Area of Snags** was also important (10 of 16) despite it being negatively correlated with 2 species. As with the adults, the abundance of broods was therefore correlated with the larger, deeper wetlands having large snag communities, high conductivities, and high pHs. Again, those associations were not apparent in the regression analyses discussed below due to variable correlation.

Figure 12 presents a PCA plot involving total brood counts of 16 species and 8 habitat variables. The first 3 principal components accounted for 45.7% of the variation. The dabbling duck and diving duck groups overlapped considerably. Mallard, Green-winged Teal, Barrow's Goldeneye, Ring-necked Duck, Bufflehead, and Canada Goose formed a tight cluster closely associated with large, deep wetlands containing large stands of snags and surrounded by forest cover. The remaining species were distributed throughout the plot forming various degrees of association with **Conductivity, Calcium, pH,** and **Area of Marsh.**

Again, **Area of Open Water** was the most important factor, entering into the regression equations for 9 of the 16 waterfowl species and on all 9

occasions it was entered first (Table 18). It was the only important variable to Total Dabblers, Total Divers, and Total Broods. The remaining variables differed in significance but, again, all were dominated by **Area of Open Water.**

Area of Open Water explained much of the variation in brood counts for Mallard (33%), Barrow's Goldeneye (55%), Bufflehead (35%), Total Divers (68%), and Total Broods (64%). Those last 2 could be accounted for primarily because Barrow's Goldeneye and Bufflehead were responsible for the majority of broods (40%). All other variables were of significantly less or no importance in explaining variation for any species.

5.5 The Effect of 4 Additional Water Chemistry Variables

The 4 "extra" water chemistry variables (**Nitrate Nitrogen, Total Dissolved Nitrogen, Total Phosphorus,** and **Turbidity**) added little to the above results (Tables 19 and 20). For adults, **Area of Open Water** was again by far the most significant variable. It was entered for 16 of the 21 regressions and, for 12 of those 16, it was entered first. It was the only important variable for Total Dabblers, Total Divers, and Total Birds.

Area of Open Water explained a considerable amount of variation in adult counts for Mallard (40%), Scaup (37%), Barrow's Goldeneye (48%), Bufflehead (58%), Total Divers (67%), and Total Birds (66%). For other species, other variables were more important: **Area of Marsh** for Pied-billed Grebe (12%) and American Coot (22%), **Total Phosphorus** for Northern Shoveler (32%) and Eared Grebe (21%), **Length Closed** for Canada Goose (23%), **Total Dissolved Nitrogen** for Gadwall (30%), and **Mean Depth** for Red-necked Grebe (17%). The remaining variables were of significantly less or no importance.

For broods, **Area of Open Water** was again the most significant variable. It was entered for 9 of the 16 waterfowl species and, for 8 of those 9, it was entered first. It was the only variable entered for Total Dabblers, Total Divers, and Total Broods.

Area of Open Water explained much of the variation in counts for Mallard (32%), Barrow's Goldeneye (51%), Bufflehead (28%), Total Divers (51%), and Total Broods (45%). **Area of Marsh** was important to Ruddy Duck (13%) and **Length Closed** was important to Ring-necked Duck (13%). The remaining variables were of significantly less or no importance for any species.

5.6 Bird-Biotic Environment Relations

Correlations between aquatic birds and the measured biotic variables were largely insignificant (Tables 21 to 28), with the following exceptions:

- Areas of filamentous algae, Potamogeton pectinatus, and Ruppia occidentalis were positively associated with both adults and broods for dabblers and divers; correlation coefficients were generally higher with the divers. R. occidentalis had relatively high coefficients of 0.55 with total diver adults and broods.
- Chironomidae larvae biomass was positively associated with dabblers and divers, although the coefficients only ranged between 0.29 and 0.38.
- The only meaningful positive relationship for the aquatic invertebrates collected in sweep nets was between dabblers and total biomass at shallow (shore) stations. The coefficients were low, however (between 0.21 and 0.35).

6. DISCUSSION

We approached this study from the habitat, instead of the species, point of view. We tried to answer the following question: "How much of the

variation in aquatic bird counts could be explained by a few, easily measured variables?". We defined a small set of variables and then determined their significance and predictive capabilities. Our approach was a broad-brush one, designed to identify general bird-habitat associations.

The variable **Area of Open Water**, representative of wetland size, was clearly the most important one describing aquatic bird numbers at Riske Creek. For both adults and broods, it was entered into the regressions for almost all species and, because it explained a large amount of the variance in the counts, it was entered first in most cases. It explained much of the variance for Total Dabblers (39% and 25% for adults and broods, respectively) and substantially more for Total Divers (70% and 68%, respectively). Such a strong positive relationship between waterfowl numbers and available wetland area has been documented by Dzubin (1969), Patterson (1976), Mack and Flake (1980), Godin and Joyner (1981), and Mulhern et al. (1985). They found that wetland size explained most of the variance in counts for several species of dabblers, including Mallard and Blue-winged Teal. Dzubin (1969), Patterson (1976), and Godin and Joyner (1981) suggested that intra-specific aggression could have been an important spacing mechanism regulating bird numbers, causing them to disperse over the available wetland area. Savard (1984, 1987, and 1988) showed that Barrow's Goldeneye and Bufflehead at Riske Creek were highly intra- and interspecifically territorial both in spring and during brood rearing. In addition to excluding each other, both species often excluded other diving ducks from their territories (Savard and Smith 1987). Such a strong spacing behaviour could account for much of the observed relationship between wetland size and diving duck numbers.

Because of variable correlations, the importance of variables other than wetland size was severely masked in the regression analyses. The fact that they were always positive when significantly correlated, and significant for

most species, means that all or a combination of the following features could be important for potential breeders and their broods: **Mean Depth, Area of Snags, Conductivity,** and **pH.**

We were surprised at the low correlations between birds and the biotic environment, particularly aquatic invertebrates. Although some associations were identified (area of R. occidentalis, Chironomidae larvae biomass, and invertebrate biomass at shore stations), the overall importance of aquatic plants and invertebrates appeared to be low.

7. SUMMARY AND LIMITATIONS

In summary, we found significant associations between aquatic birds and several habitat variables at Riske Creek. The importance of **Mean Depth, Area of Snags, Conductivity,** and **pH** was, however, masked in the regression equations for most species because of their moderately high correlations with **Area of Open Water.** If the relationship between wetland size and bird abundance is indeed a biologically meaningful one, then some spacing mechanism was likely distributing the birds in proportion to wetland availability (size).

In addition to the above, other possible study limitations are:

1. Our method of correlating bird counts measured over 5 years with habitat data collected over only 1 "average" year may have diluted species-habitat associations. We felt that the advantages of such an approach would outweigh the costs of collecting and analysing bird-habitat associations for each year.
2. Habitat associations might have been more apparent if some variables had had larger ranges (e.g. pH was relatively restricted). There simply might not have been sufficient feature variability in our study area for selection to occur or to be observed.

3. Our data set covered a wide range of biological, physical, and chemical characteristics. Despite that, it is possible that some important, uncorrelated variable was missed. That problem is unlikely for the dominant species Barrow's Goldeneye and Bufflehead; **Area of Open Water** explained so much of the variation in their abundance that little remained for any other variable(s).

4. Aquatic birds at Riske Creek may have been responding to a number of wetland characteristics simultaneously and, in turn, they may have been using the wetlands as a major complex. High mobility between wetlands and the use of wetland complexes by Mallards have been documented by Dwyer and Krapu (1979) and Talent et al. (1982).

5. Some of the relationships between birds and abiotic factors may not have been linear.

8. RECOMMENDATIONS

We recommend that the role of territoriality be investigated further at Riske Creek to determine its effect on spacing and habitat selection. Radio-tracking of females and their broods should be used to follow movements, to determine reasons for those movements, and to map habitat use. In conjunction with that investigation, the role of Riske Creek wetlands as a complex should be assessed. Comparisons with other complexes in other biogeoclimatic zones could be undertaken to evaluate similarities and differences in aquatic bird populations and habitat characteristics.

Finally, we recommend that bird-habitat relationship studies be carried out in an experimental manner. Hypotheses should be developed and an attempt should be made to hold constant as many variables as possible while allowing only one or a few of the key ones to vary. Wetlands should be grouped by size

class, and migrants, pairs, broods, and molters should be intensively surveyed over a period of at least 3 years.

A major study, as outlined above, would satisfy some of the key information requirements for understanding habitat relationships of aquatic birds breeding in the central interior of British Columbia.

LITERATURE CITED

Adamus, R. 1983. A method for wetland functional assessment: Vol. II. FHWA assessment method. Federal Highway Administration. U.S. Dept. of Transportation Report No. FHWA-IP-82-24.

Annas, R.M. and R. Coupe. 1979. Biogeoclimatic zones and subzones of the Cariboo Forest Region, Province of British Columbia. Ministry of Forests, Research Branch. 104pp.

Boyd, W.S. and J-P.L. Savard. 1987. Abiotic and biotic characteristics of wetlands at Riske Creek, British Columbia - a data report. Technical Report Series No. 16. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 120pp.

Boyd, W.S. and D.W. Smith. 1989. Summary of aquatic invertebrate data collected from wetlands at Riske Creek, British Columbia, 1984 and 1985. Technical Report Series No. 60. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 35pp.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep water habitats of the U.S. U.S. Fish and Wildlife Service. Biological Services Program. FWS/OBS-79/31. 103pp.

Dannell, K. and K. Sjoberg. 1978. Habitat selection by breeding ducks in boreal lakes in Northern Sweden. Viltrevy Sweden Wildlife 10(7): 160-188.

Dwyer, T.J. and G.L. Krapu. 1979. Use of prairie pothole habitat by breeding Mallards. J. Wildl. Manage. 43(2):526-531.

Dzubin, A. 1969. Comments on carrying capacity of small ponds for ducks and possible effects of density on Mallard production. In: Saskatoon Wetlands Seminar. Canadian Wildlife Service Report Series 6: 138-171.

Godin, P.R. and D.E. Joyner. 1981. Pond ecology and its influence on Mallard use in Ontario, Canada. Wildfowl 32: 28-34.

Gollop, J.B. and W.H. Marshall. 1954. A guide for aging duck broods in the field. Miss. Flyway Counc. Tech. Sect. 14pp.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. Univ. of Washington Press, Seattle. 730pp.

Holland, S.S. 1976. Landforms of British Columbia - A physiographic outline. B.C. Dept. of Mines and Petroleum Resources. Bull. 48. 138pp.

Kaminski, R.M. and H.H. Prince. 1984. Dabbling duck habitat associations during spring in Delta Marsh, Manitoba. J. Wildl. Manage. 48(1): 37-50.

Larson, J.S. 1976. Models for assessment of freshwater wetlands. Western Resources Research Center, Univ. Mass. Pub. No. 32.

Mack, G.D. and L.D. Flake. 1980. Habitat relationships of waterfowl broods on South Dakota stock ponds. J. Wildl. Manage. 44(3): 695-700.

McKelvey, R. and W. Munro. 1983. Cooperative waterfowl management plan for British Columbia. Unpubl. regional report, Canadian Wildlife Service, Pacific and Yukon Region, Delta, British Columbia and British Columbia Fish and Wildlife Branch, Victoria, British Columbia. 26pp.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547pp.

Mulhern, J.H., T.D. Nudds, and B.R. Neal. 1985. Wetland selection by Mallards and Blue-winged Teal. Wilson Bull. 97(4): 473-485.

Murphy, S.M., B. Kessel and L.J. Vining. 1984. Waterfowl populations and limnologic characteristics of taiga ponds. J. Wildl. Manage. 48(4): 1156-1163.

Nilsson S.G. and I.N. Nilsson. 1978. Breeding bird community densities and species richness in lakes. Oikos 31: 214-221.

Patterson, J.H. 1976. The role of environmental heterogeneity in the regulation of duck populations. J. Wildl. Manage. 40(1): 22-32.

Reppert, R.T., W. Siegleo, E. Stakhiv, L. Messman, and C.D. Meyers. 1979. Wetland values: concepts and methods for wetland evaluation. Institute for Water Resources. U.S. Army Corps of Engineers. Research Report 79-RI.

Runka, G.G. and T. Lewis. 1981. Preliminary wetland managers manual. Cariboo Resource Management Region. APD Technical Paper 5. B.C. Ministry of Environment. 112pp.

Savard, J-P.L. 1984. Territorial behaviour of Common Goldeneye, Barrow's Goldeneye and Bufflehead in areas of sympatry. Ornis. Scand. 15: 211-216.

Savard, J.-P.L. 1987. Causes and functions of brood amalgamation in Barrow's Goldeneye and Bufflehead. Can. J. Zool. 65: 1548-1553.

Savard, J.-P.L. 1988. Winter, spring and summer territoriality in Barrow's Goldeneye: characteristics and benefits. Ornis Scand. 19: 119-128.

Savard, J.-P.L. and J.N.M. Smith 1987. Interspecific aggression by Barrow's Goldeneye: a descriptive and functional analysis. Behaviour 102: 168-184.

Sokal, R.R. and E.J. Rohlf. 1969. Biometry. The principles and practice of statistics in biological research. W.H. Freeman and Company. San Francisco. 776pp.

SPSS Inc. 1986. User's Guide SPSS:X, Second Edition, 1986, McGraw-Hill, New York, New York.

Taber, R.D. 1971. Criteria of sex and age. In Wildlife Management techniques, R.H. Giles Jr. ed., The Wildl. Soc. Washington, D.C.: 325-402.

Talent, L.G., G.L. Krapu, and R.L. Jarvis. 1982. Habitat use by Mallard broods in south central North Dakota. J. Wildl. Manage. 46(3): 629-635.

Tipper, H.W. 1971. Glacial geomorphology and Pleistocene history of central British Columbia. Geol. Surv. Can., Bull. 196. 89pp.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J. 620pp.

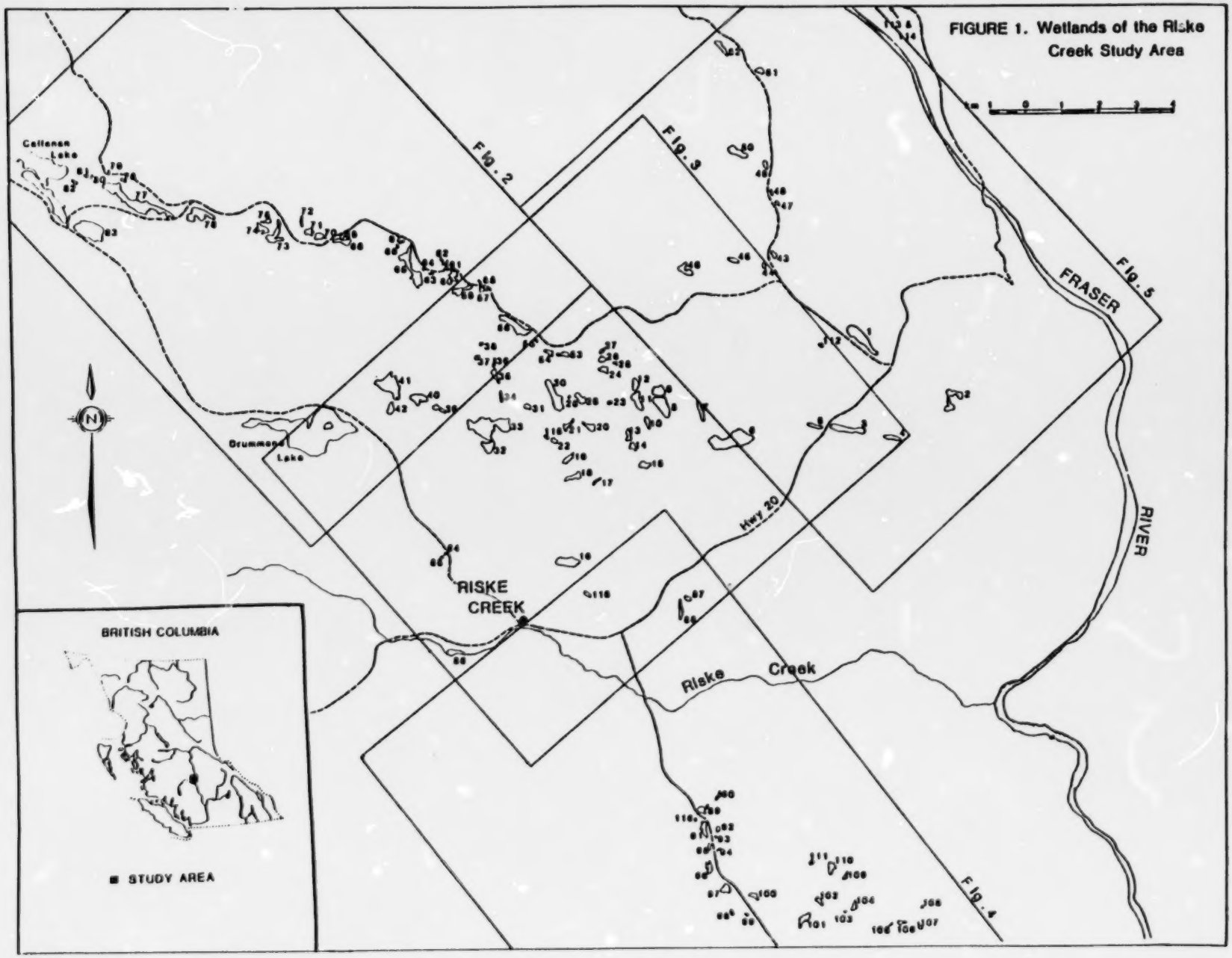


FIGURE 1. Wetlands of the Riske Creek Study Area
Callanan Lake
Drummond Lake
RISKE CREEK
Riske Creek
Hwy 20
FRASER
RIVER
Fig. 2
Fig. 3
Fig. 4
Fig. 5
BRITISH COLUMBIA
STUDY AREA

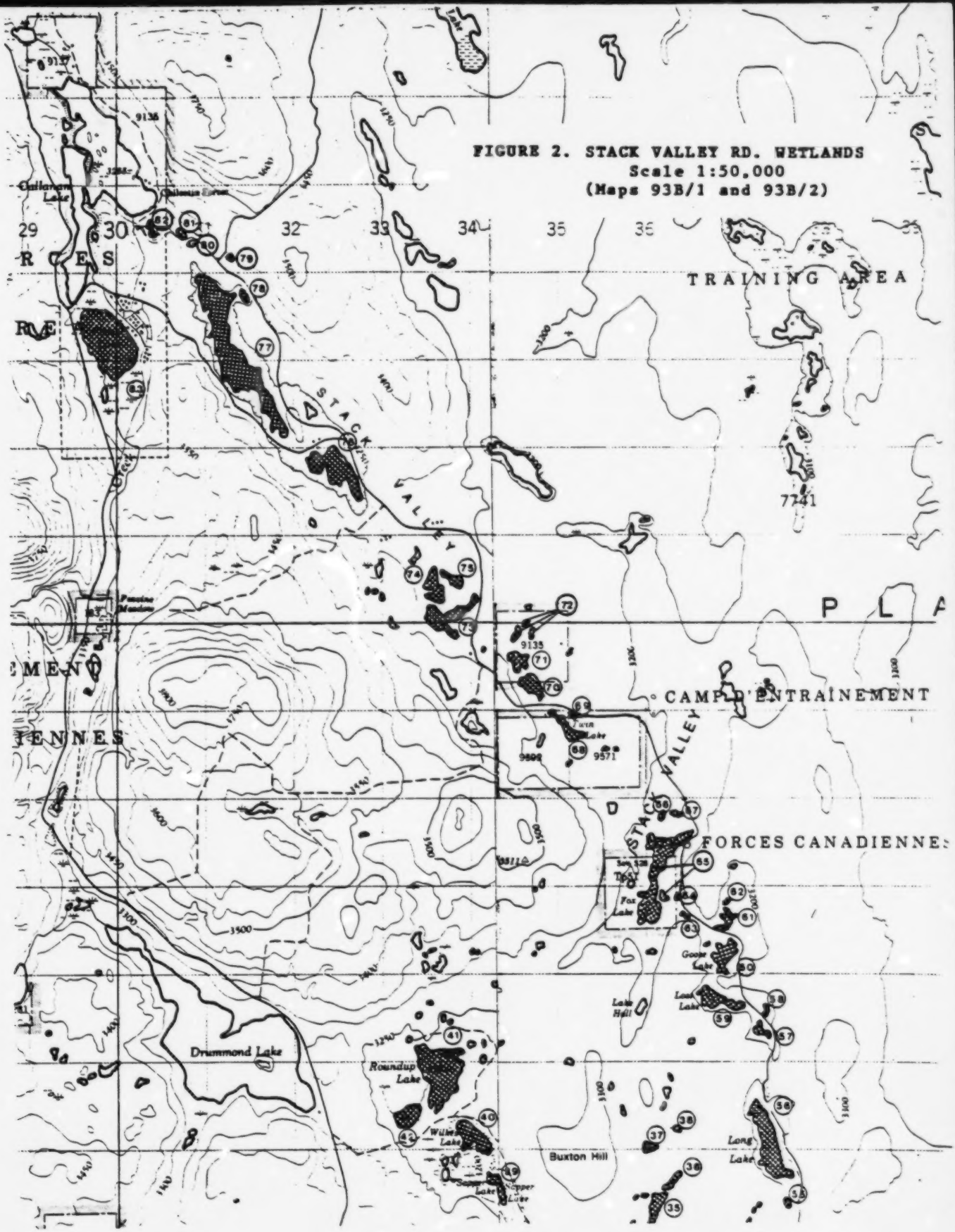


FIGURE 2. STACK VALLEY RD. WETLANDS
Scale 1:50,000
(Maps 93B/1 and 93B/2)

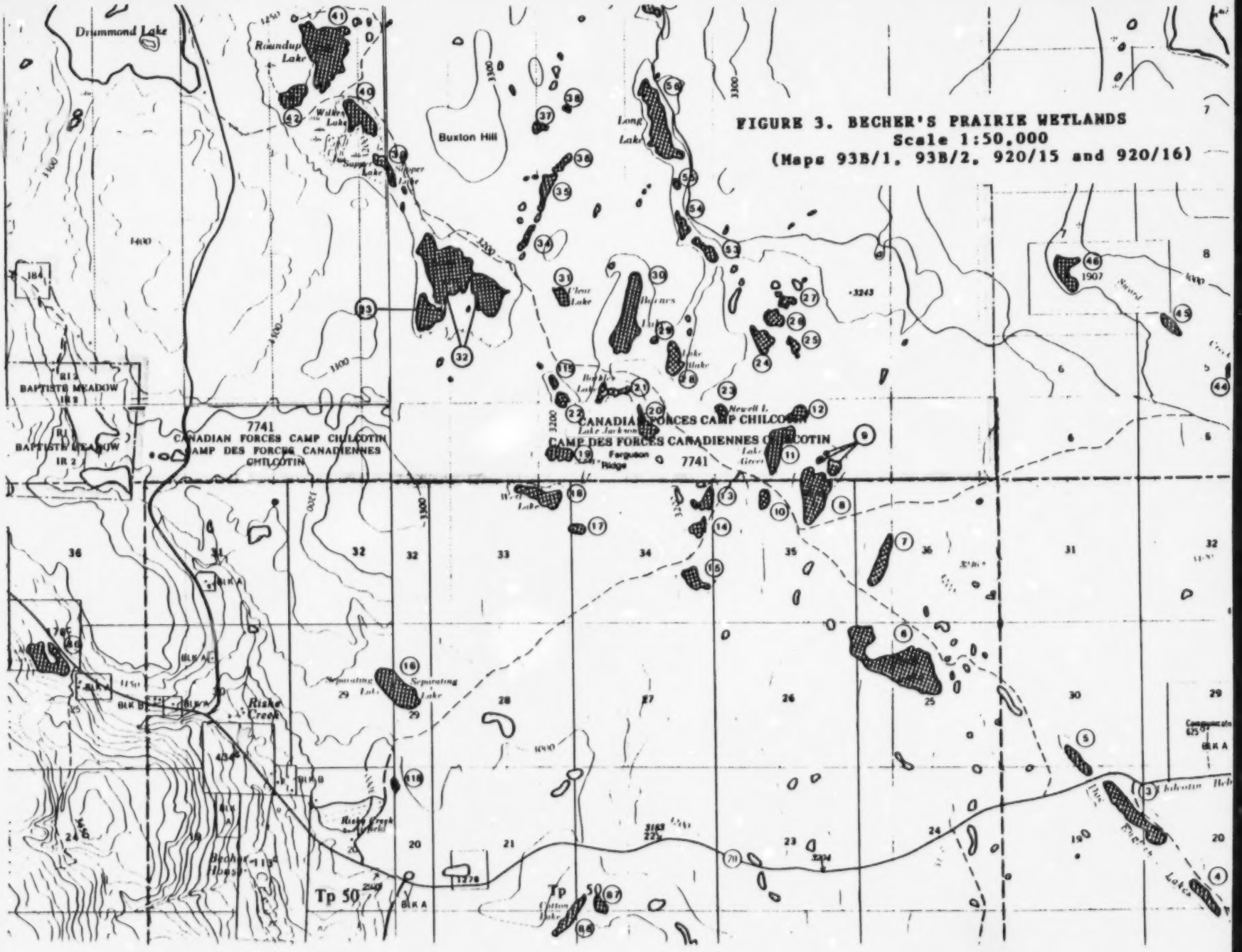


FIGURE 3. BECHER'S PRAIRIE WETLANDS
Scale 1:50,000
(Maps 93B/1, 93B/2, 920/15 and 920/16)

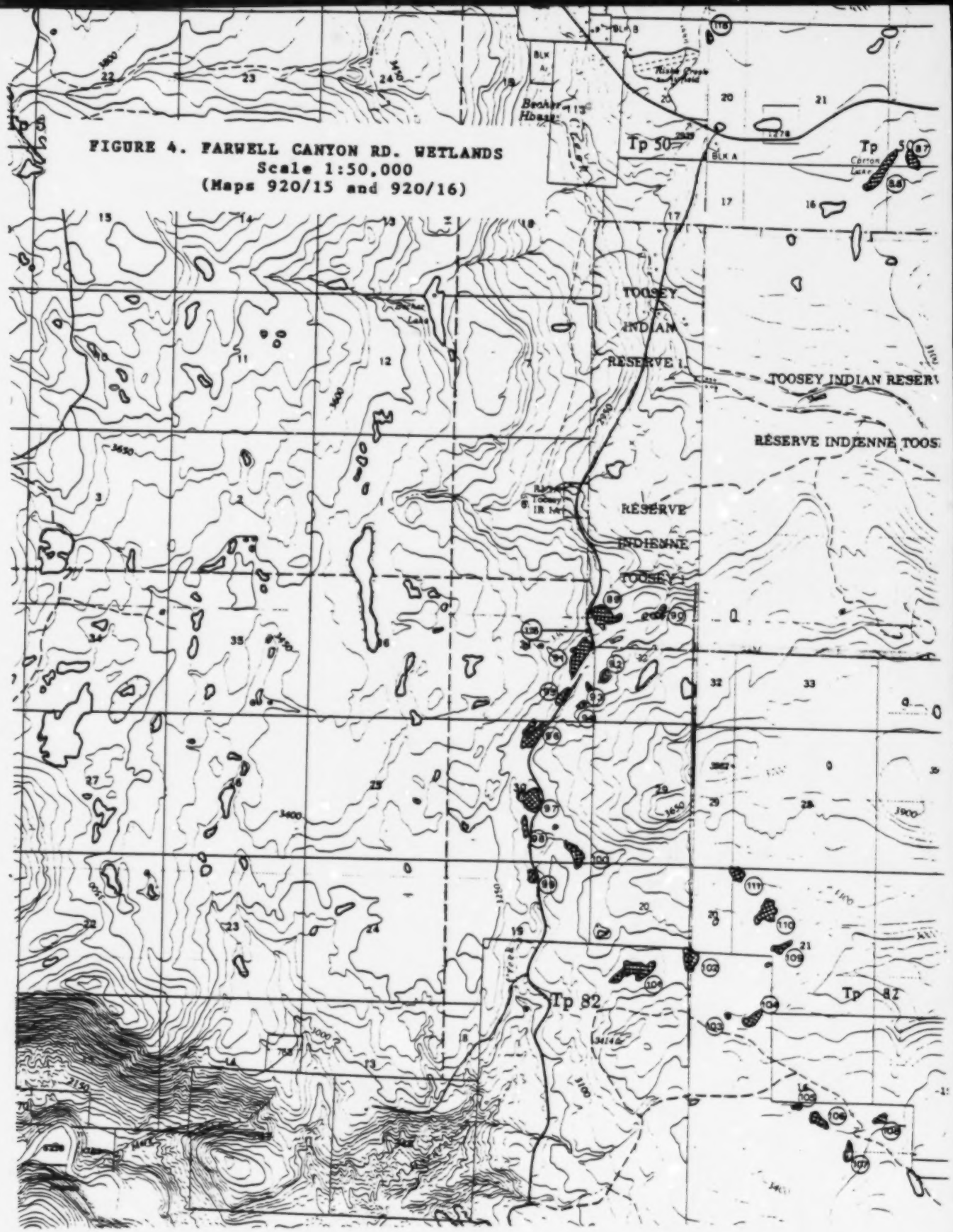


FIGURE 4. FARWELL CANYON RD. WETLANDS
Scale 1:50,000
(Maps 920/15 and 920/16)

FIGURE 5. MELDRUM CREEK RD. WETLANDS
Scale 1:50,000
(Maps 920/16 and 93B/1)

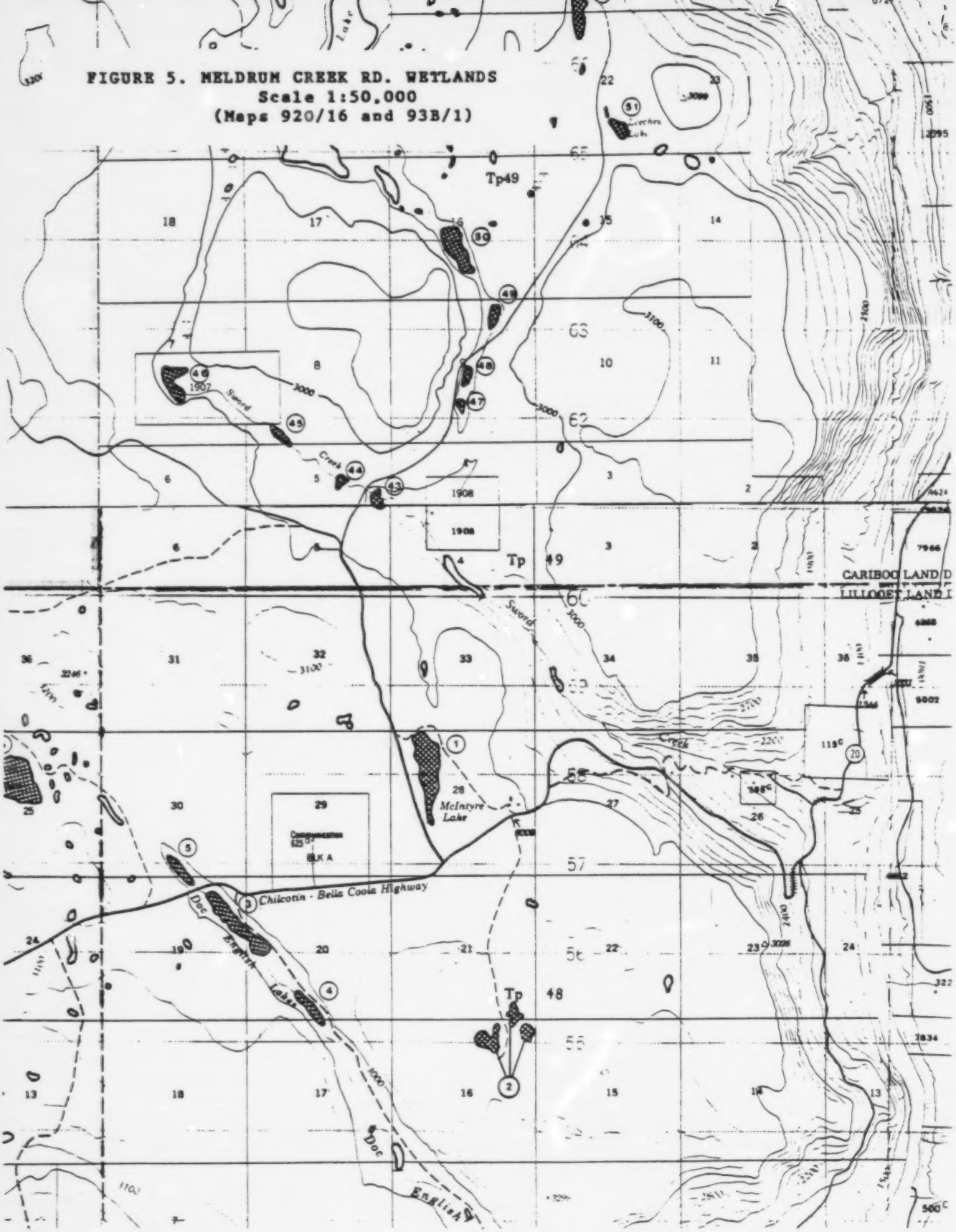
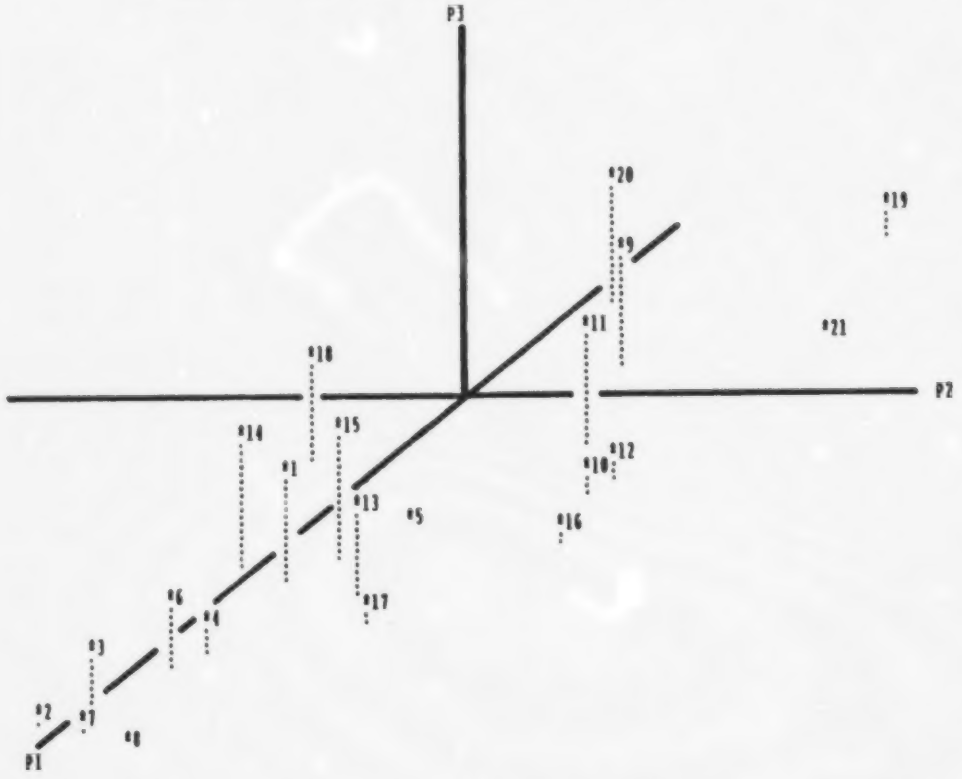


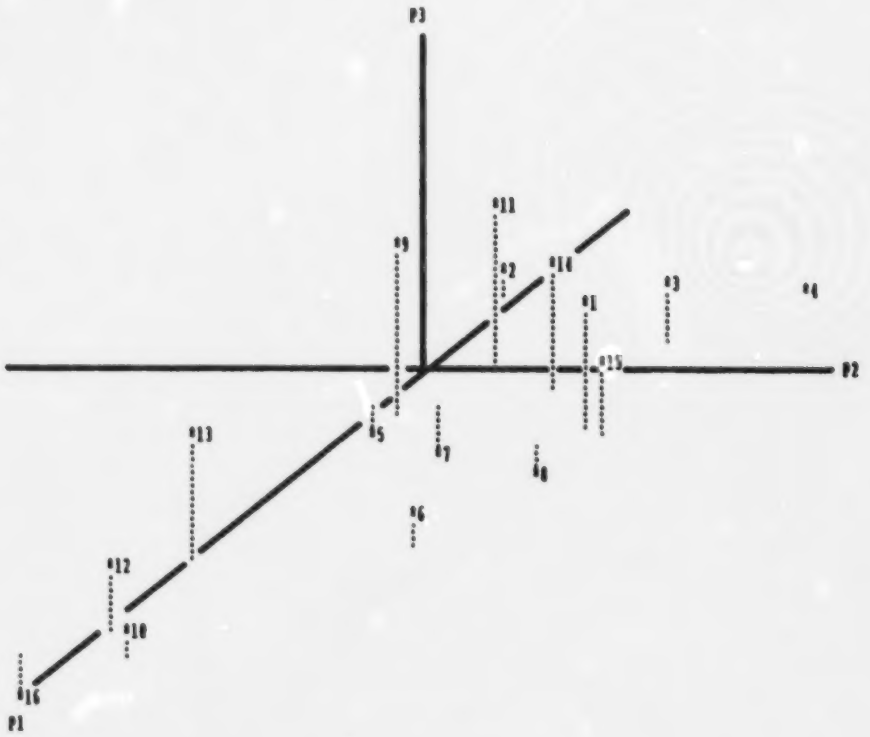
Figure 6. Plot of the first 3 principal components for mean adult counts of 21 aquatic bird species (potential breeders only) over 112 Riske Creek wetlands. Values were log transformed prior to analysis. All coordinates were weighted by their eigenvalues.



NO.	ID	P1	P2	P3	NO.	ID	P1	P2	P3
1	Mallard	14.776	2.162	6.276	12	Canvasback	6.430	11.613	1.216
2	Northern Pintail	25.974	-1.828	0.105	13	Scaup sp.	15.727	6.086	5.040
3	Green-winged Teal	23.918	-0.208	2.675	14	Barrow's Goldeneye	13.320	-0.682	7.441
4	Blue-winged Teal	20.388	2.466	1.840	15	Bufflehead	13.007	3.627	7.460
5	Cinnamon Teal	9.417	4.393	-0.203	16	Ruddy Duck	11.403	12.817	0.614
6	American Wigeon	21.630	1.516	3.717	17	Eared Grebe	17.867	8.074	0.826
7	Northern Shoveler	22.044	1.417	0.584	18	Horned Grebe	4.744	-3.743	6.034
8	Gadwall	27.624	4.068	-0.311	19	Pied-billed Grebe	-13.467	10.317	1.818
9	Canada Goose	-2.789	5.508	6.551	20	Red-necked Grebe	-8.261	1.043	6.868
10	Redhead	7.449	11.256	1.269	21	American Coot	-5.391	12.988	-0.218
11	Ring-necked Duck	3.425	8.131	6.607					

AXIS	P1 (diagonal)	P2 (horizontal)	P3 (vertical)
PERCENT OF VARIATION	33.5	15.4	10.6

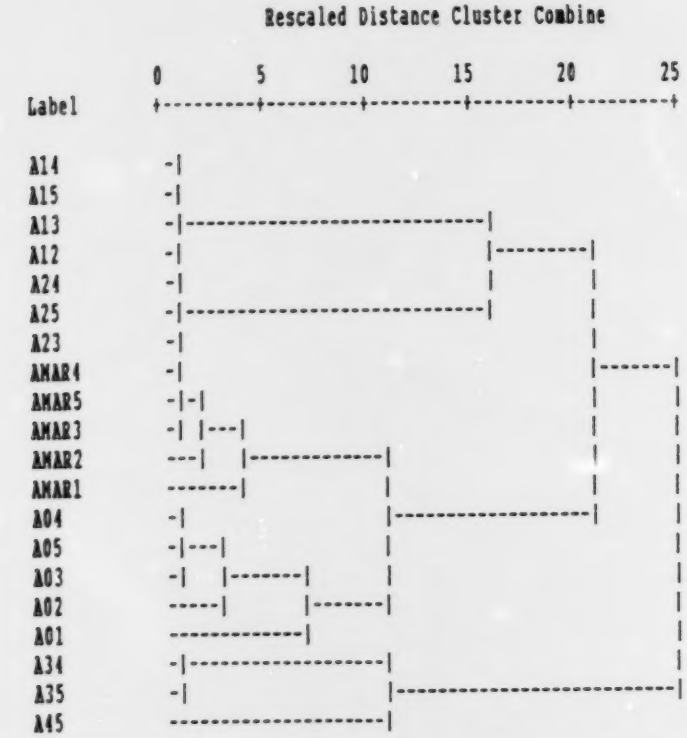
Figure 7. Plot of the first 3 principal components for total brood counts of 16 aquatic bird species over 112 Riske Creek wetlands. Values were log transformed prior to analysis. All coordinates were weighted by their eigenvalues.



NO.	ID	P1	P2	P3	NO.	ID	P1	P2	P3
1	Mallard	3.456	0.442	5.521	9	Canada Goose	2.029	0.899	7.866
2	Northern Pintail	-5.202	-0.930	0.670	10	Redhead	18.752	1.963	0.861
3	Green-winged Teal	-2.055	7.519	2.565	11	Ring-necked Duck	-0.910	2.044	7.059
4	Blue-winged Teal	-4.055	10.882	-0.003	12	Canvasback	17.303	0.516	2.784
5	Cinnamon Teal	2.454	-0.382	-1.390	13	Scaup sp.	12.426	0.041	5.444
6	American Wigeon	11.632	7.921	1.244	14	Barrow's Goldeneye	1.012	5.575	5.485
7	Northern Shoveler	2.380	2.192	-2.588	15	Bufflehead	4.053	9.504	3.130
8	Gadwall	6.924	7.639	-1.583	16	Ruddy Duck	18.933	-2.095	-2.039

AXIS	P1 (diagonal)	P2 (horizontal)	P3 (vertical)
PERCENT OF VARIATION	23.6	14.3	10.5

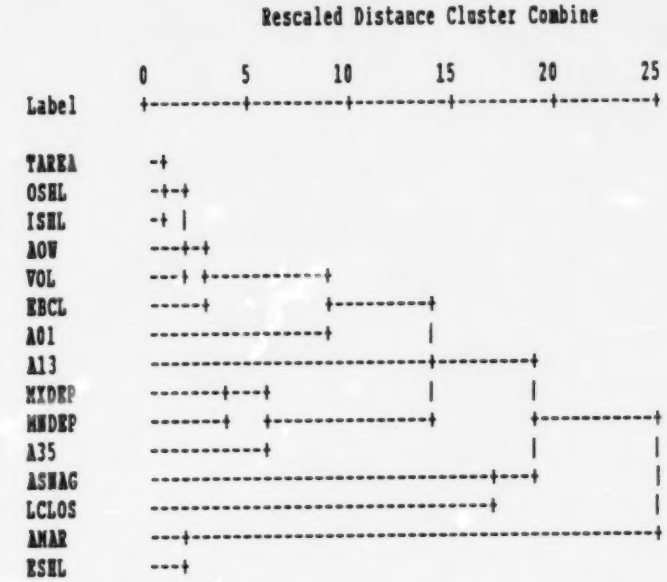
Figure 8. Hierarchical cluster dendrogram for various combinations of bottom contour areas over 112 Riske Creek wetlands (average linkage between groups) based on absolute values of correlation coefficients. Values were log transformed prior to analysis.



Legend examples:

A01 - Area between 0 and 1 m depth
AMAR1 - Area between the outer marsh edge and 1 m depth

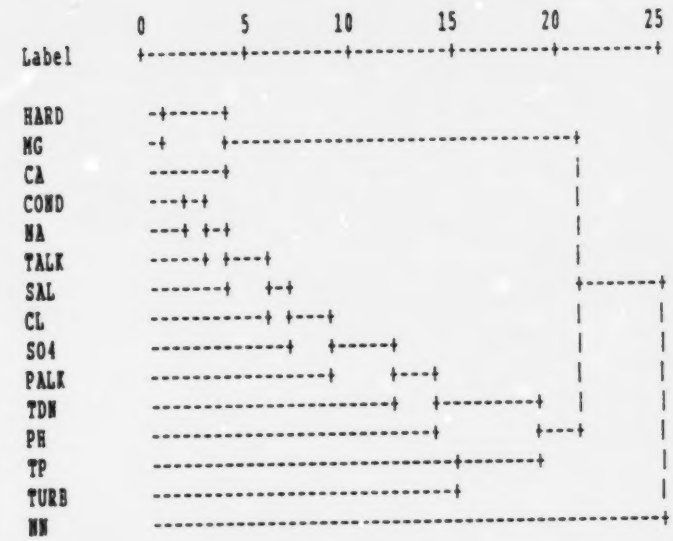
Figure 9. Heirarchical cluster dendrogram for various morphometric parameters over 112 Riske Creek wetlands (average linkage between groups) based on absolute values of correlation coefficients. Values were log transformed prior to analysis.



Legend:

TAREA - Total area of wetland
A01 - Area between 0 and 1 m depth
A13 - " " 1 " 3 m "
A35 - " " 3 " 5 m "
VOL - Volume of water in wetland
MXDEP - Maximum depth
MNDEP - Mean depth
AOW - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
OSHL - Outer shoreline length
ISHL - Inner shoreline length
ESHL - Emergent shoreline length
EBCL - Edge between classes
LCLOS - Length of forested perimeter

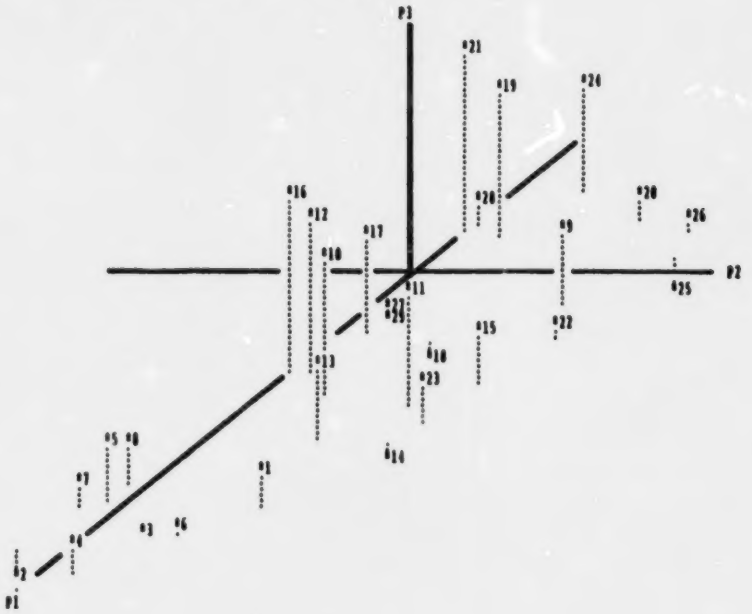
Figure 10. Heirarchical cluster dendrogram for various water chemistry parameters over 92 Riske Creek wetlands (average linkage between groups) based on absolute values of correlation coefficients. Values were log transformed prior to analysis.



Legend:

PH	- pH	MG	- Magnesium
COND	- Conductivity	CL	- Chloride
SAL	- Salinity	SO4	- Sulphate
CA	- Calcium	NN	- Nitrate Nitrogen
NA	- Sodium	TDN	- Total Dissolved Nitrogen
PALK	- Phenol Alkalinity	TP	- Total Phosphorus
TALK	- Total Alkalinity	TURB	- Turbidity
HARD	- Hardness		

Figure 11. Plot of the first 3 principal components for mean adult counts of 21 aquatic bird species (potential breeders only) and 8 habitat variables over 112 Riske Creek wetlands. Values were log transformed prior to analysis. All coordinates were weighted by their eigenvalues.



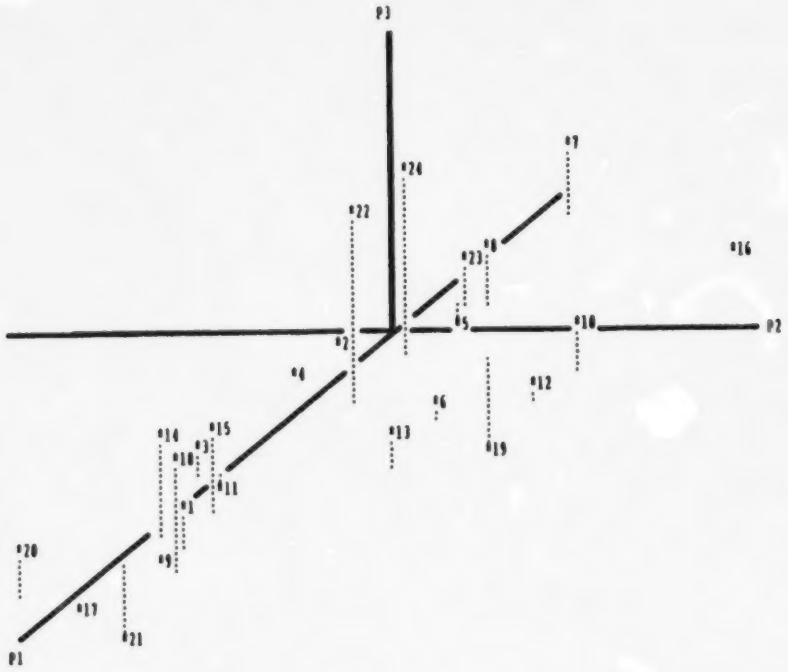
NO.	ID	P1	P2	P3	NO.	ID	P1	P2	P3
1	Mallard	18.035	6.309	1.033	16	Ruddy Duck	7.079	-0.334	9.346
2	Northern Pintail	21.544	-2.348	-1.430	17	Eared Grebe	4.148	1.142	5.079
3	Green-winged Teal	19.648	2.267	-0.243	18	Horned Grebe	5.092	0.696	-1.079
4	Blue-winged Teal	23.286	1.654	1.576	19	Pied-billed Grebe	-3.087	1.992	0.210
5	Cinnamon Teal	17.543	-0.066	3.142	20	Red-necked Grebe	-4.271	7.326	1.409
6	American Wigeon	19.999	4.097	0.167	21	American Coot	-3.545	-0.019	9.929
7	Northern Shoveler	17.703	-1.960	1.171	22	MDEP	4.085	9.081	0.793
8	Gadwall	15.917	-0.905	1.987	23	AOW	11.143	0.545	2.089
9	Canada Goose	2.114	0.306	3.985	24	AMAR	-6.760	2.969	5.016
10	Redhead	8.995	2.593	7.226	25	ASNAG	-1.556	10.701	-2.113
11	Ring-necked Duck	9.908	6.606	6.082	26	LCLOS	-3.721	9.749	0.490
12	Canvasback	7.332	0.085	0.475	27	COND	3.541	1.988	0.731
13	Scaup sp.	12.630	4.017	3.993	28	CA	-3.949	0.247	1.419
14	Barrow's Goldeneye	12.925	0.306	-0.000	29	PH	3.360	1.501	0.005
15	Bufflehead	8.152	0.045	2.504					

AXIS	P1 (diagonal)	P2 (horizontal)	P3 (vertical)
PERCENT OF VARIATION	20.9	13.5	11.4

Legend:

MDEP - Mean depth
AOW - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH

Figure 12. Plot of the first 3 principal components for total brood counts of 16 aquatic bird species and 8 habitat variables over 112 Biske Creek wetlands. Values were log transformed prior to analysis. All coordinates were weighted by their eigenvalues.



NO.	ID	P1	P2	P3	NO.	ID	P1	P2	P3
1	Mallard	14.310	2.005	1.719	13	Scaup sp.	8.950	6.166	1.440
2	Northern Pintail	0.600	-1.017	-0.233	14	Barrow's Goldeneye	13.440	0.503	4.442
3	Green-winged Teal	9.416	-0.799	1.036	15	Bufflehead	11.704	1.240	3.653
4	Blue-winged Teal	2.691	-2.012	-0.004	16	Ruddy Duck	-5.020	9.399	-0.099
5	Cinnamon Teal	-1.993	1.167	-1.141	17	MDEP	10.504	1.145	-0.027
6	American Wigeon	5.061	5.048	0.727	18	AOW	15.021	2.818	5.002
7	Northern Shoveler	-7.691	1.705	3.144	19	ANAR	1.640	4.772	-4.614
8	Gadwall	-1.722	2.230	2.647	20	ASWAG	17.640	-1.029	2.045
9	Canada Goose	15.617	1.979	0.159	21	LCLOS	15.579	0.613	-3.606
10	Redhead	2.709	8.548	2.133	22	COND	0.455	1.650	0.613
11	Ring-necked Duck	9.515	0.080	-0.716	23	CA	-2.017	1.277	1.051
12	Canvasback	4.576	0.513	0.539	24	PH	1.510	1.445	0.520

AXIS	P1 (diagonal)	P2 (horizontal)	P3 (vertical)
PERCENT OF VARIATION	23.6	11.7	10.4

Legend:

MDEP - Mean depth
AOW - Area of open water
ANAR - Area of marsh
ASWAG - Area of dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH

Table 1. Mean value and variability of 8 major wetland habitat variables measured at Riske Creek, 1983-1984 (n=112; variable definitions are given in Table 12).

VARIABLE	MEAN	STANDARD DEVIATION	MINIMUM	PERCENTILE 25%	PERCENTILE 50%	PERCENTILE 75%	MAXIMUM
MEAN DEPTH (m)	1.2	0.6	0.1	0.8	0.9	1.4	3.6
AREA OF OPEN WATER (ha)	4.2	6.5	0.2	0.7	2.1	4.5	40.8
AREA OF MARSH (ha)	0.4	0.6	0.0	0.1	0.2	0.6	3.5
AREA OF SNAG (ha)	0.1	0.3	0.0	0.0	0.0	0.1	2.8
LENGTH CLOSED (m)	287	518	0.0	24	93	308	4055
CONDUCTIVITY (umhos/cm)	2132	2694	42	664	1240	2247	17050
CALCIUM (ppm)	95	91	0.0	31	75	125	563
PH	9.1	0.6	7.0	8.8	9.2	9.5	10.1

Table 2. Dates of aquatic bird surveys at Riske Creek, 1980-1984. ("*" denotes a survey during which many wetlands were frozen.)

Survey No.	Survey Date		
	Year	Month	Day
1	1980	April	24*
2			25
3		May	7
4			11
5			21
6			23
7	1981	April	27
8			30
9		May	10
10			16
11	1982	April	27*
12			29*
13		May	9
14			15
15			25
16	1983	April	27
17			29
18		May	7
19			9
20	1984	April	29
21		May	3
22			10
23			14
24			27

Table 3. Relative abundance of aquatic bird species on the Riske Creek study area, 1980-1984 (total number of adult birds over 21 surveys; migrants included).

SPECIES	TOTAL COUNT	PERCENT OF TOTAL
DABBLING DUCKS AND GEESE		
1. Mallard (Anas platyrhynchos)	4078	4.5
2. Northern Pintail (A. acuta)	2028	2.3
3. Green-winged Teal (A. crecca)	4392	4.9
4. Blue-winged Teal (A. discors)	3804	4.2
5. Cinnamon Teal (A. cyanoptera)	396	0.4
6. American Wigeon (A. americana)	6779	7.6
7. Northern Shoveler (A. clypeata)	2446	2.7
8. Gadwall (A. strepera)	623	0.7
9. Canada Goose (Branta canadensis)	1073	1.2
DIVING DUCKS		
10. Redhead (Aythya americana)	1468	1.6
11. Ring-necked Duck (A. collaris)	2909	3.3
12. Canvasback (A. valisineria)	2642	3.0
13. Scaup Sp. (A. marilla and A. affinis)	19241	21.6
14. Barrow's Goldeneye (Bucephala islandica)	14737	16.5
15. Bufflehead (B. albeola)	8873	10.0
16. Ruddy Duck (Oxyura jamaicensis)	3154	3.5
GREBES AND COOTS		
17. Eared Grebe (Podiceps nigricollis)	2595	2.9
18. Horned Grebe (P. auritus)	632	0.7
19. Pied-billed Grebe (Podilymbus podiceps)	119	0.1
20. Red-necked Grebe (Podiceps grisegena)	176	0.2
21. American Coot (Fulica americana)	5487	6.2
OTHER SPECIES[1]		
22. Surf Scoter (Melanitta perspicillata)	991	1.1
23. Common Loon (Gavia immer)	151	0.2
24. Eurasian Wigeon (Anas penelope)	5	-
25. Swan Sp. (Olor sp.)	9	-
26. Oldsquaw (Clangula hyemalis)	54	0.1
27. White-winged Scoter (Melanitta deglandi)	90	0.1
28. Common Goldeneye (Bucephala clangula)	88	0.1
29. Hooded Merganser (Lophodytes cucullatus)	71	0.1
30. Western Grebe (Aechmophorus occidentalis)	2	-
TOTAL	89113	100

1 - These species were not used in our analysis because they were either entirely migrants or their numbers were too low.

Table 4. Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	PINT	GWTE	BWTE	CITE	WIGE	SHOV	GADW	CAGO	REDH	RNDU	CANV	SCAU	BAGO	BUFF	RUDU	EAGR	HOGR	PBGR	RNGR	COOT
MALL	.3696	.4701	.5230	.3002	.5000	.3758	.3327	.2917	.3260	.5625	.2209	.4036	.5807	.5530	.2904	.2661	.3597	.1161	.1046	.0929
PINT		.5523	.4745	.2921	.4729	.7019	.5724	-.0046	.0784	.0971	.1200	.2527	.3578	.1600	.2165	.1849	.1706	-.2325	-.1160	-.2134
GWTE			.5404	.2463	.4017	.5951	.5320	.2172	.2124	.2122	.1569	.3909	.4031	.4455	.2270	.2853	.2446	-.1201	-.0584	-.1132
BWTE				.5146	.5603	.4587	.4320	.1417	.3387	.3204	.2021	.5197	.3726	.3631	.2748	.2444	.1031	-.0381	-.0436	.0024
CITE					.2374	.3000	.2225	.1071	.2359	.2510	.2922	.2985	.1042	.1625	.2803	.1284	-.0424	.1029	-.0156	.2305
WIGE						.4021	.5279	.1402	.4438	.4262	.2502	.4483	.5651	.4355	.2695	.3247	.2117	-.1388	.0126	-.0273
SHOV							.6688	.0865	.1454	.1522	.2693	.3950	.2722	.3294	.3344	.4451	.1804	-.1439	-.0236	-.0313
GADW								.0373	.3720	.2493	.3296	.4157	.3197	.3075	.4565	.5647	-.0127	-.1584	-.1224	.0614
CAGO									.3523	.5761	.3060	.3611	.2957	.4042	.1758	.2127	.0888	.0077	.4272	.1927
REDH										.5237	.5770	.4283	.1782	.3866	.6171	.3651	-.1084	.4061	-.0484	.4074
RNDU											.5074	.4837	.4418	.4765	.4685	.2929	.1858	.4082	.3828	.3592
CANV												.4788	.1768	.2924	.6899	.3347	-.0075	.4607	.0478	.4954
SCAU													.5535	.6328	.5819	.4668	.1357	.1488	.1742	.1467
BAGO														.6229	.1366	.1396	.3646	.0889	.2534	-.1115
BUFF															.3913	.4469	.4051	.0618	.2797	.1611
RUDU																.6124	.0843	.4186	.0441	.6736
EAGR																	-.0361	-.0220	.0068	.3763
HOGR																		-.0358	.1692	-.1165
PBGR																			.1558	.6261
RNGR																				.1241

Note: R values below .185 are not significant at the 0.05 level.

Legend:

MALL	- Mallard	REDH	- Redhead	PBGR	- Pied-billed Grebe
PINT	- Northern Pintail	RNDU	- Ring-necked Duck	RNGR	- Red-necked Grebe
GWTE	- Green-winged Teal	CANV	- Canvasback	COOT	- American Coot
BWTE	- Blue-winged Teal	SCAU	- Scaup sp.		
CITE	- Cinnamon Teal	BAGO	- Barrow's Goldeneye		
WIGE	- American Wigeon	BUFF	- Bufflehead		
SHOV	- Northern Shoveler	RUDU	- Ruddy Duck		
GADW	- Gadwall	EAGR	- Eared Grebe		
CAGO	- Canada Goose	HOGR	- Horned Grebe		

Table 5. Relative abundance of waterfowl broods on the Riske Creek study area, 1980-1984, based on the total number of broods (total number of broods recorded over 5 years).

SPECIES	TOTAL NUMBER OF BROODS	PERCENT OF TOTAL
1. Mallard	195	9.5
2. Northern Pintail	20	1.0
3. Green-winged Teal	118	5.7
4. Blue-winged Teal	227	11.0
5. Cinnamon Teal	3	0.2
6. American Wigeon	177	8.6
7. Northern Shoveler	64	3.1
8. Gadwall	34	1.7
9. Canada Goose	65	3.1
10. Redhead	50	2.4
11. Ring-necked Duck	24	1.2
12. Canvasback	41	2.0
13. Scaup Sp.	108	5.2
14. Barrow's Goldeneye	459	22.3
15. Bufflehead	367	17.8
16. Ruddy Duck	108	5.2
TOTAL	2060	100

Table 6. Relative abundance of waterfowl broods on the Riske Creek study area, 1980-1984, based on the maximum number of broods (highest number of broods on each wetland recorded in any one of the 5 years, summed over all wetlands).

	SPECIES	TOTAL OF MAXIMUM NUMBER OF BROODS	PERCENT OF TOTAL
1.	Mallard	95	9.5
2.	Northern Pintail	15	1.5
3.	Green-winged Teal	63	6.3
4.	Blue-winged Teal	121	12.1
5.	Cinnamon Teal	3	0.3
6.	American Wigeon	93	9.3
7.	Northern Shoveler	48	4.8
8.	Gadwall	26	2.6
9.	Canada Goose	23	2.3
10.	Redhead	33	3.3
11.	Ring-necked Duck	17	1.7
12.	Canvasback	22	2.2
13.	Scaup Sp.	66	6.6
14.	Barrow's Goldeneye	167	16.8
15.	Bufflehead	143	14.4
16.	Ruddy Duck	61	6.1
	TOTAL	996	100

Table 7. Pearson correlation coefficients between total and maximum number of broods counted on 112 Riske Creek wetlands.

Species	R
Mallard	.9340
Northern Pintail	.9375
Green-winged Teal	.9163
Blue-winged Teal	.9199
Cinnamon Teal	1.0000
American Wigeon	.9158
Northern Shoveler	.9629
Gadwall	.9496
Canada Goose	.8897
Redhead	.9567
Ring-necked Duck	.9690
Canvasback	.9363
Scaup sp.	.9510
Barrow's Goldeneye	.9640
Bufflehead	.9329
Ruddy Duck	.9598
Mean	.9435

Table 8. Correlation matrix between total brood counts of 16 aquatic bird species over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	PINT	GWTE	BWTE	CITE	WIGE	SHOV	GADW	CAGO	REDH	RNDU	CANV	SCAU	BAGO	BUFF	RUDU
MALL	.0985	.3952	.3740	-.0301	.4451	.0860	.1971	.3605	.2212	.3057	.2499	.3295	.5619	.5205	-.0486
PINT		.0860	.0972	-.0612	-.0077	.2347	.1326	-.0843	-.1902	-.1363	-.1369	-.0167	.2511	-.2567	-.1817
GWTE			.2917	.0833	.2575	.0825	.1429	.1729	.0259	.1438	.0483	.1200	.3321	.2909	-.1184
BWTE				-.0797	.2766	.0539	.2742	-.0128	-.1028	.1834	-.0074	.0018	.2392	.3341	-.2010
CITE					-.0116	.0509	-.0871	-.0504	.0833	-.0614	.1339	-.0260	-.0638	.0008	.0362
WIGE						.1414	.3168	.2294	.3975	.0725	.3556	.3148	.3016	.3526	.1978
SHOV							.2313	-.1296	.0211	-.1885	.0013	-.0267	.2035	-.1068	-.0107
GADW								.0986	.2364	-.0842	.0630	.0653	.1966	.1724	.0042
CAGO									.2167	.4143	.1989	.3043	.2999	.2569	-.0893
REDH										.0916	.4918	.3260	.1142	.2561	.5004
RNDU											.2262	.2222	.1672	.2023	-.1279
CANV												.4247	.1762	.1860	.4862
SCAU													.2836	.2302	.2980
BAGO														.3531	-.1514
BUFF															.0388

Note: R values below .185 are not significant at the 0.05 level.

Legend:

MALL	-	Mallard	REDH	-	Redhead
PINT	-	Northern Pintail	RNDU	-	Ring-necked Duck
GWTE	-	Green-winged Teal	CANV	-	Canvasback
BWTE	-	Blue-winged Teal	SCAU	-	Scaup sp.
CITE	-	Cinnamon Teal	BAGO	-	Barrow's Goldeneye
WIGE	-	American Wigeon	BUFF	-	Bufflehead
SHOV	-	Northern Shoveler	RUDU	-	Ruddy Duck
GADW	-	Gadwall			
CAGO	-	Canada Goose			

Table 9. Correlation matrix for various combinations of bottom contour areas over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log tranformed prior to analysis.

	A12	A23	A34	A45	A02	A03	A04	A05	A13	A14	A15	A24	A25	A35	AMAR1	AMAR2	AMAR3	AMAR4	AMAR5
A01	.2072	.1107	.1951	.1514	.9129	.8282	.7944	.7051	.1990	.1995	.2006	.1198	.1212	.1961	.7078	.6463	.6097	.5994	.5976
A12		.5554	.3499	.2552	.5331	.6051	.6131	.6121	.9945	.9916	.9907	.5542	.5538	.3496	.3477	.5660	.6124	.6210	.6220
A23			.6215	.4361	.3198	.5387	.5848	.5927	.6222	.6369	.6401	.9983	.9974	.6205	.1975	.3312	.4749	.5100	.5174
A34				.7359	.3056	.4206	.5289	.5522	.3887	.4255	.4341	.6577	.6646	.9995	.1903	.2630	.3441	.4190	.4365
A45					.2375	.2966	.3904	.4320	.2748	.3072	.3211	.4727	.4864	.7523	.1675	.2075	.2476	.3112	.3398
A02						.9536	.9279	.9195	.5245	.5245	.5252	.3205	.3215	.3064	.7342	.7833	.7685	.7631	.7618
A03							.9881	.9814	.6258	.6294	.6305	.5384	.5387	.4206	.7032	.7738	.8164	.8201	.8202
A04								.9980	.6378	.6407	.6512	.5925	.5941	.5291	.6855	.7591	.8098	.8284	.8316
A05									.6374	.6497	.6534	.6021	.6050	.5541	.6800	.7531	.8047	.8263	.8319
A13										.9988	.9981	.6208	.6203	.3882	.3450	.5614	.6265	.6380	.6395
A14											.9990	.6381	.6380	.4251	.3460	.5611	.6286	.6448	.6473
A15												.6418	.6421	.4342	.3469	.5614	.6291	.6463	.6495
A24													.9998	.6570	.1995	.3318	.4748	.5149	.5235
A25														.6644	.2008	.3324	.4749	.5159	.5253
A35															.1919	.2637	.3441	.4192	.4378
AMAR1																.9547	.9201	.9062	.9023
AMAR2																	.9811	.9700	.9662
AMAR3																		.9951	.9922
AMAR4																			.9992

Note: R values below .185 are not significant at the 0.05 level.

Legend examples:

A01 - Area between 0 and 1 m depth
AMAR1 - Area between the outer marsh edge and 1 m depth

Table 10. Correlation matrix for various morphometric variables over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	A01	A13	A35	VOL	MXDEP	MNDEP	AOV	AMAR	ASNAG	OSHL	ISHL	RSHL	EBCL	LCLOS
TAREA	.7720	.6167	.5594	.9612	.6687	.5759	.9509	.1926	.4539	.9682	.9395	.2966	.9227	.3521
A01		.1595	.1870	.6651	.1398	.1864	.6312	.4092	.1075	.7752	.6937	.3605	.7719	.2887
A13			.3839	.6437	.7936	.4933	.7208	-.0740	.4286	.5744	.6509	.0990	.5400	.2013
A35				.6818	.7423	.8385	.5702	-.0202	.5290	.5296	.5449	.0807	.4672	.3229
VOL					.8037	.7687	.9215	.1975	.5101	.9277	.9110	.3124	.8913	.4204
MXDEP						.8754	.7247	.0139	.5668	.6372	.6878	.1847	.6107	.3463
MNDEP							.5761	.1267	.5211	.5510	.5728	.2365	.5387	.4354
AOV								.0306	.4913	.9068	.9451	.2127	.8508	.2637
AMAR									-.0113	.1892	.1047	.9289	.4418	.3895
ASNAG										.4650	.4937	.1122	.4205	.4591
OSHL											.9522	.2795	.9444	.3697
ISHL												.2531	.9162	.3316
RSHL													.5439	.3717
EBCL														.4275

Note: R values below .185 are not significant at the 0.05 level.

Legend:

TAREA - Total area of wetland
A01 - Area between 0 and 1 m depth
A13 - " " 1 " 3 m "
A35 - " " 3 " 5 m "
VOL - Volume of water in wetland
MXDEP - Maximum depth
MNDEP - Mean depth
AOV - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
OSHL - Outer shoreline length
ISHL - Inner shoreline length
RSHL - Emergent shoreline length
EBCL - Edge between classes
LCLOS - Length of forested perimeter

Table 11. Correlation matrix for various water chemistry variables over 92 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	COND	SAL	CA	NA	PALK	TALK	HARD	MG	CL	SO4	NN	TDN	TP	TURB
PH	.5430	.4142	-.0959	.5015	.6027	.5648	.1462	.1452	.4315	.4306	.0445	.5520	.2633	.2729
COND		.9252	.2069	.9390	.7489	.8998	.5554	.5529	.8251	.8195	.1326	.6359	.3619	.2472
SAL			.0375	.8496	.6638	.7563	.4032	.4097	.8314	.8116	.1437	.5044	.3992	.2259
CA				.0783	.0430	.1039	.8697	.8362	-.0999	.1714	-.0474	.0246	-.4079	-.1001
NA					.7332	.8818	.4361	.4481	.7852	.7856	.2012	.7379	.3874	.3056
PALK						.7446	.3247	.3370	.6487	.6250	.0266	.5552	.3452	.1908
TALK							.4192	.4150	.7823	.6209	.1460	.6174	.4067	.1628
HARD								.9832	.2387	.4752	.0282	.3193	-.1639	.0597
MG									.2428	.4690	.0237	.3237	-.1829	.0222
CL										.6921	.0612	.4766	.4778	.2188
SO4											.1036	.6110	.3196	.3668
NN												.2061	.1823	.1570
TDN													.4060	.5626
TP														.4641

Note: R values below .203 are not significant at the 0.05 level.

Legend:

PH - pH
COND - Conductivity
SAL - Salinity
CA - Calcium
NA - Sodium
PALK - Phenol Alkalinity
TALK - Total Alkalinity
HARD - Hardness
MG - Magnesium
CL - Chloride
SO4 - Sulphate
NN - Nitrate-Nitrogen
TDN - Total Dissolved Nitrogen
TP - Total Phosphorus
TURB - Turbidity

Table 12. Brief descriptions of the habitat variables used in data analysis.

Variable	Details
"Major" Variables for 112 Wetlands	
1. Mean Depth (m)	- depth to bottom of wetland averaged over all bottom contours.
2. Area of Open Water (ha)	- area of wetland excluding marsh communities but including aquatic plant communities; maximum depth greater than 2m.
3. Area of Marsh (ha)	- area of persistent emergent plants, usually around the edge of wetlands; includes deep and shallow marsh.
4. Area of Snag (ha)	- area of dead trees standing or lying in shallow water.
5. Length Closed (m)	- length of forested surroundings along wetland perimeter averaged up to 100 m from wetland/upland boundary.
6. Conductivity (μmhos/cm)	- measure of the total concentration of salts in the water; related to productivity.
7. Calcium (ppm)	- required nutrient in normal metabolism of higher plants.
8. pH (pH units)	- measure of acidity; logarithm of the reciprocal of the concentration of free hydrogen ions.
"Extra" Variables for 92 wetlands	
9. Nitrate Nitrogen (ppm)	
10. Total Dissolved Nitrogen (ppm)	
11. Total Phosphorus (ppm)	
12. Turbidity (turbidity units)	

Table 13. Correlation matrix between 8 major habitat variables over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	AOW	AMAR	ASNAG	LCLOS	COND	CA	PH
MDEP	.5761	.1267	.5211	.4360	.1189	.0346	.0897
AOW		.0306	.4913	.2640	.5038	-.0685	.4688
AMAR			-.0113	.3907	-.2856	-.0636	-.1946
ASNAG				.4594	.2333	-.0229	.2000
LCLOS					-.1536	-.0345	-.1432
COND						.3031	.6017
CA							.0975

Note: R values below .185 are not significant at the 0.05 level.

Legend:

MDEP - Mean depth
AOW - Area of open water
AMAR - Area of marsh
ASNAG - Area ot dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH

Table 14. Correlation matrix between 12 habitat variables over 92 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	AOW	AMAR	ASNAG	LCLOS	COND	CA	PH	NN	TDN	TP	TURB
MDEP	.5099	.0828	.4904	.3972	.0768	-.0115	.0522	.0636	-.1296	-.0913	-.3274
AOW		.0198	.4841	.2559	.5102	-.1523	.4542	.1050	.1683	.2450	.0011
AMAR			.0150	.3452	-.2786	-.0689	-.1449	.0268	-.2792	-.1316	-.2918
ASNAG				.4831	.2178	-.0742	.2145	-.0092	-.0296	-.0569	-.1413
LCLOS					-.1406	-.0798	-.1171	-.1120	-.3676	-.2389	-.4103
COND						.2066	.5530	.1406	.6313	.3643	.2554
CA							-.0916	-.0410	.0230	-.4121	-.0964
PH								.0688	.5601	.2715	.2656
NN									.2093	.1724	.1497
TDN										.4077	.5723
TP											.4715

Note: R values below .203 are not significant at the 0.05 level.

Legend:

MDEP - Mean depth
AOW - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH
NN - Nitrate Nitrogen
TDN - Total Dissolved Nitrogen
TP - Total Phosphorus
TURB - Turbidity

Table 15. Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) and 8 habitat variables over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	MDEP	AOV	AMAR	ASNAG	LCLOS	COND	CA	PH
MALL	.3676	.6356	.0607	.3181	.2072	.2253	-.0273	.1584
PINT	.0464	.3070	-.3549	-.0013	-.2695	.2750	-.1910	.2598
GWTE	.1967	.4430	-.0003	.1626	.0561	.2777	-.2299	.1669
BWTE	.2395	.4710	-.0084	.0149	-.0049	.1237	-.0659	.2433
CITE	.1458	.2299	-.0655	-.0632	-.0931	.0614	.1261	.0963
WIGE	.2780	.4580	-.1478	.2042	.0629	.2589	-.1904	.2647
SHOV	.0310	.4173	-.1923	-.0386	-.2618	.4345	-.2535	.3131
GADW	.0378	.3627	-.1328	.0378	-.1960	.3609	-.3425	.3374
CAGO	.3549	.4274	.2471	.3772	.4499	.1186	.0384	.0836
REDH	.1355	.2585	.2135	.0906	.1080	.1394	.0266	.0976
RNDU	.3617	.4754	.1998	.2302	.2043	.1634	.1021	.0451
CANV	.1526	.2935	.2468	-.0696	.0383	.1376	.0135	.1804
SCAU	.3830	.6451	-.0406	.2281	-.0121	.4686	.0795	.3617
BAGO	.5503	.7328	-.1840	.4862	.2280	.5322	.0516	.4248
BUFF	.5732	.7760	.1140	.5030	.3095	.4140	-.1391	.3127
RUDU	.1811	.3225	.2281	-.0930	-.1163	.2008	-.0428	.1335
EAGR	.1115	.4103	.0905	.0950	-.0442	.2955	-.3270	.2835
HOGR	.2914	.3680	.0757	.2520	.2128	.1694	-.1367	.0463
PBGR	.1108	.0904	.3425	-.0235	.2253	.0090	.2820	-.1008
RNGR	.4432	.3291	.1095	.3798	.2698	.1308	.2108	.0152
COOT	.0635	.1249	.4546	-.1259	.0990	.0472	.1446	.0098

Note: R values below .185 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL - Mallard
PINT - Northern Pintail
GWTE - Green-winged Teal
BWTE - Blue-winged Teal
CITE - Cinnamon Teal
WIGE - American Wigeon
SHOV - Northern Shoveler
GADW - Gadwall
CAGO - Canada Goose
REDH - Redhead
RNDU - Ring-necked Duck
CANV - Canvasback
SCAU - Scaup sp.
BAGO - Barrow's Goldeneye
BUFF - Bufflehead
RUDU - Ruddy Duck
EAGR - Eared Grebe
HOGR - Horned Grebe
PBGR - Pied-billed Grebe
RNGR - Red-necked Grebe
COOT - American Coot

HABITAT VARIABLES:

MDEP - Mean depth
AOV - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH

Table 16. Stepwise multiple regression results for mean adult counts (potential breeders only) of 21 aquatic bird species against 8 habitat variables over 112 Riske Creek wetlands. Cumulative R^2 values (x100) are shown with associated signs of their final regression coefficients (only negative signs are presented). The first variable entered corresponds to the lowest R^2 value. Probability of variable entry into a regression equation was set at 0.05 (F-test). Variable entry was terminated if R^2 was not increased by more that 5%. Values were log transformed prior to analysis.

Species	Mean Depth	Area Open Water	Area Marsh	Area Snag	Length Closed	Conductivity	Calcium	pH
1. Mallard		40						
2. Northern Pintail		23	13-	30-				
3. Green-winged Teal		20						
4. Blue-winged Teal		22		28-				
5. Cinnamon Teal								
6. American Wigeon		21						
7. Northern Shoveler						19	35-	
8. Gadwall		13				36	23-	
9. Canada Goose		31			20			
10. Redhead		7						
11. Ring-necked Duck		23						
12. Canvasback		9		15-				
13. Scaup sp.		42						
14. Barrow's Goldeneye		54						
15. Bufflehead		60						
16. Ruddy Duck		10		19-				
17. Eared Grebe		17				32	26-	
18. Horned Grebe		14						
19. Pied-billed Grebe			12				21	
20. Red-necked Grebe	20							
21. American Coot			21					
No. times entered	1	16	3	4	1	3	4	0
No. times entered first	1	14	3	0	1	1	0	0
Total Dabblers		39						
Total Divers		70						
Total Birds		69						

Table 17. Correlation matrix between total brood counts of 16 aquatic bird species and 8 habitat variables over 112 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	MDEP	AOV	AMAR	ASNAG	LCLOS	COND	CA	PH
MALL	.5006	.5767	.1047	.4276	.3120	.2826	-.0460	.2861
PINT	-.0176	.0463	-.3777	-.1041	-.2694	.1066	-.0495	-.0285
GWTE	.2806	.3423	-.0254	.3134	.1629	.2319	-.1627	.0729
BWTE	.1721	.2371	.0871	.1925	.0980	-.0278	-.0173	.1551
CITE	-.0716	-.0922	-.0365	-.1038	.0224	-.1228	.0301	-.1754
WIGE	.3127	.3629	.1129	.1451	.0852	.1161	-.0973	.2579
SHOV	-.1473	.0492	-.1186	-.2142	-.4556	.2282	.0654	.1943
GADW	-.0703	.2689	-.0380	-.0094	-.2462	.1805	-.3184	.2681
CAGO	.4377	.3985	.1532	.4636	.3522	.2225	.0758	.0933
REDH	.1189	.3772	.2554	.0625	.0549	.2404	-.0166	.2349
RNDU	.2122	.1788	.0972	.3382	.3331	.0831	.2433	.0175
CANV	.1997	.2955	.1937	.1214	.2082	.1767	.1724	.1846
SCAU	.2717	.3816	.0268	.2465	.1841	.2745	.2499	.1985
BAGO	.4621	.7385	-.2099	.3070	.1108	.4743	-.0073	.3584
BUFF	.4413	.5874	.1575	.4980	.3286	.2772	-.1052	.3483
RUDU	-.0499	.0146	.3577	-.2614	-.0168	.1060	.1423	.0443

Note: R values below .185 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL - Mallard
PINT - Northern Pintail
GWTE - Green-winged Teal
BWTE - Blue-winged Teal
CITE - Cinnamon Teal
WIGE - American Wigeon
SHOV - Northern Shoveler
GADW - Gadwall
CAGO - Canada Goose
REDH - Redhead
RNDU - Ring-necked Duck
CANV - Canvasback
SCAU - Scaup sp.
BAGO - Barrow's Goldeneye
BUFF - Bufflehead
RUDU - Ruddy Duck

HABITAT VARIABLES:

MDEP - Mean depth
AOV - Area of open water
AMAR - Area of marsh
ASNAG - Area of dead trees (snags)
LCLOS - Length of forested perimeter
COND - Conductivity
CA - Calcium
PH - pH

Table 18. Stepwise multiple regression results for total brood counts of 16 aquatic bird species against 8 habitat variables over 112 Riske Creek wetlands. Cumulative R^2 values (x100) are shown with associated signs of their final regression coefficients (only negative signs are presented). The first variable entered corresponds to the lowest R^2 value. Probability of variable entry into a regression equation was set at 0.05 (F-test). Variable entry was terminated if R^2 was not increased by more than 5%. Values were log-transformed prior to analysis.

Species	Mean Depth	Area Open Water	Area Marsh	Area Snag	Length Closed	Conductivity	Calcium	pH
1. Mallard		33						
2. Northern Pintail			14-					
3. Green-winged Teal		12						
4. Blue-winged Teal		6						
5. Cinnamon Teal								
6. American Wigeon		13						
7. Northern Shoveler					21-			
8. Gadwall					24-		10-	
9. Canada Goose				22				
10. Redhead		14	20					
11. Ring-necked Duck				11			18	
12. Canvasback		9						
13. Scaup sp.		15					22	
14. Barrow's Goldeneye		55						
15. Bufflehead		35						
16. Ruddy Duck			13	19-		28		
No. times entered	0	9	3	3	2	1	3	0
No. times entered first	0	9	2	2	1	0	1	0
Total Dabblers		25						
Total Divers		68					71	72
Total Broods		64						

Table 19. Stepwise multiple regression results for mean adult counts (potential breeders only) of 21 aquatic bird species against the 8 major habitat variables plus 4 "extra" water chemistry variables over 92 Riske Creek wetlands. Cumulative R^2 values (x100) are shown with associated signs of their final regression coefficients (only negative coefficients are presented). The first variable entered corresponds to the lowest R^2 value. Probability of variable entry into a regression equation was set at 0.05 (F-test). Variable entry was terminated if R^2 was not increased by more than 5%. Values were log transformed prior to analysis.

Species	Mean Depth	Area Open Water	Area Marsh	Area Snag	Length Closed	Conductivity	Calcium	pH	Nitrate Nitrogen	Total Dissolved Nitrogen	Total Phosphorus	Turbidity
1. Mallard		40										
2. Northern Pintail		28	16-	36-								
3. Green-winged Teal		18										
4. Blue-winged Teal		15		22-								
5. Cinnamon Teal												
6. American Wigeon		20										
7. Northern Shoveler		45			52-						32	
8. Gadwall							38-			30		
9. Canada Goose		32			23							
10. Redhead		7										
11. Ring-necked Duck		21										
12. Canvasback		8	21	15-								
13. Scaup sp.		37			43-							
14. Barrow's Goldeneye		48	55-									
15. Bufflehead		58										
16. Ruddy Duck		10		21-								
17. Eared Grebe		32									21	
18. Horned Grebe		19										
19. Pied-billed Grebe			12				21					
20. Red-necked Grebe	17											
21. American Coot			22						28			
No. times entered	1	16	5	4	3	0	2	0	1	1	2	0
No. times entered first	1	12	3	0	1	0	0	0	0	1	2	0
Total Dabblers		35		41-								
Total Divers		67										
Total Birds		66										

Table 20. Stepwise multiple regression results for total brood counts of 16 aquatic bird species against the 8 major habitat variables plus 4 "extra" water chemistry variables over 92 Riske Creek wetlands. Cumulative R^2 values (x100) are shown with associated signs of their final regression coefficients (only negative signs are presented). The first variable entered corresponds to the lowest R^2 value. Probability of variable entry into a regression equation was set at 0.05 (F-test). Variable entry was terminated if R^2 was not increased by more than 5%. Values were log transformed prior to analysis.

Species	Mean Depth	Area Open Water	Area Marsh	Area Snag	Length Closed	Conductivity	Calcium	pH	Nitrate Nitrogen	Total Dissolved Nitrogen	Total Phosphorus	Turbidity
1. Mallard		32									38-	
2. Northern Pintail			26-									
3. Green-winged Teal		13										
4. Blue-winged Teal										6-		
5. Cinnamon Teal												
6. American Wigeon		8										
7. Northern Shoveler					30-							
8. Gadwall		28			21-		13-					
9. Canada Goose				21-								
10. Redhead		13	21									
11. Ring-necked Duck					13		23					19-
12. Canvasback		12										
13. Scaup sp.		11					20					
14. Barrow's Goldeneye		51	60-									
15. Bufflehead		28										
16. Ruddy Duck			13	21-		27						
No. times entered	0	9	4	2	3	1	3	0	0	1	1	1
No. times entered first	0	8	2	1	2	0	1	0	0	1	0	0
Total Dabblers		11										
Total Divers		>2										
Total Birds		45										

Table 21 . Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) and 21 aquatic plant species abundance values over 112 Riske Creek wetlands (Pearson correlation coefficients). All values were log transformed prior to analysis.

	AQUATIC PLANT SPECIES																					
BIRD SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TAREA
MALL	.2581	.0171	-.1171	-.1044	.0424	.3017	-.1299	-.0572	-.1369	.0591	.0766	-.0633	.0022	.2259	.0433	-.0381	.4131	-.0125	-.1068	-.1644	-.0329	.2669
PINT	.1183	-.0753	-.0202	-.2159	-.0061	.0966	-.1446	-.2120	-.0665	-.0026	-.0472	-.0529	-.0511	.1488	-.0170	-.0928	.1931	-.0358	-.0862	-.1914	.2867	.1600
GWTE	.2599	-.0577	-.1713	-.1767	-.1770	.0007	-.1584	-.0475	-.2072	-.0806	-.1078	-.0746	-.0768	.0888	-.0355	-.1761	.1550	-.1068	-.0585	-.1109	.0729	-.0607
BWTE	.2677	.1069	-.1278	-.1228	.0481	.2898	-.0128	.0352	.1007	.1967	.1612	.0391	-.1416	.2039	-.1478	.0642	.2429	-.0526	-.1192	-.1365	-.0368	.2866
CITE	.2757	.1509	.0274	-.0107	-.1289	.2169	.2241	.1494	.1277	-.0106	-.0025	.2017	-.1677	.1241	-.0604	.2020	.1240	-.1531	-.1036	-.0019	.0347	.2609
WIGE	.2671	-.0053	-.1061	-.2713	.0170	.2226	-.1573	-.0645	-.2310	-.0091	-.0629	-.1483	-.1294	.2266	-.0605	-.2020	.3941	-.1161	-.1561	-.2027	.0210	.2176
SHOV	-.0473	-.0616	-.0388	-.3552	-.1017	.2407	-.0963	-.1284	-.1137	-.0312	-.1767	-.0497	-.1748	.1848	-.0991	-.2299	.2089	-.1858	-.0556	-.1710	.2946	.0264
GADW	.2434	-.0815	-.1339	-.4063	-.1558	.2218	-.1462	-.1729	-.1259	-.0753	-.2019	-.0801	-.1930	.3163	-.1301	-.2561	.2239	-.2150	-.1601	-.2326	.1405	.0596
CAGO	-.0286	-.0477	.2042	.2523	-.0722	.1911	.0163	-.1175	-.1086	-.0333	-.0832	-.1533	-.0357	.0402	.0318	-.0786	.3193	-.0556	-.0675	.1053	-.1272	.0751
REDH	.2961	.0850	.1661	-.0216	-.1057	.3505	.0681	-.0707	-.0711	-.0000	-.1543	-.0279	-.1114	.3312	-.1157	-.1359	.3943	-.1700	-.1074	.1370	-.1372	.2911
RNDU	.2187	-.0338	.1171	.0614	-.1007	.3981	-.0150	-.1459	-.2109	-.0228	-.0993	-.1127	-.1213	.3497	-.0008	-.1094	.5804	-.1177	-.1130	.0513	-.1435	.3786
CANV	-.0042	.0250	.2938	-.0704	-.1298	.4424	.0352	-.1787	-.1071	-.0752	-.1809	-.0340	-.1523	.4116	-.1007	-.1751	.4303	-.1600	-.0790	.1353	-.0014	.3202
SCAU	.2894	-.0176	-.0474	-.1932	-.0729	.2865	-.1209	-.0942	-.0621	.0428	-.1174	-.0830	-.2800	.2508	-.2250	-.2125	.3904	-.2593	-.2687	-.1876	-.1763	.1110
BAGO	.2755	-.1754	-.0393	-.3915	-.0093	.1609	-.2284	-.2186	-.2897	-.0145	-.0442	-.1715	-.2884	.2307	-.2181	-.2623	.4339	-.2718	-.3115	-.3660	-.1149	-.0370
BUFF	.1764	-.0253	-.1407	-.1431	-.0051	.2274	-.1870	-.1438	-.2820	.0479	-.0175	-.2176	-.1046	.0244	-.0946	-.1906	.4011	-.1458	-.2143	-.1727	-.2346	-.0640
RUDU	.1871	.0981	.1005	-.1525	-.1523	.4705	.0061	-.0894	-.0835	-.0830	-.1803	-.0223	-.1701	.3247	-.1208	-.2324	.4384	-.2287	-.1416	.0607	-.0885	.2739
EAGR	.0862	-.0592	-.0952	-.2598	-.1000	.3112	-.1283	-.0775	-.1501	-.0545	-.1287	-.1404	-.1169	.2006	-.0788	-.2015	.3062	-.1535	-.1174	-.1423	-.0779	.0801
HOGR	-.0055	-.0559	.0237	-.0625	.1144	-.0202	-.0505	-.1155	-.1484	.1011	.0413	-.1876	.0332	-.0074	.0471	-.0350	.1912	.1157	.0504	-.0859	.0508	-.1020
PBGR	.0274	.2101	.4907	.1912	-.1018	.3630	.3554	.0696	.0049	-.0555	-.0741	.1056	-.1191	.2191	-.0802	-.0294	.1960	-.1563	-.0520	.2900	-.0835	.2549
RNGR	-.0601	-.1263	-.0184	.0694	-.0158	.2244	-.1105	-.0864	-.2038	.0482	-.0648	-.2248	-.0840	.1239	-.0566	-.0947	.3292	-.0891	-.0844	-.0753	-.0822	.1354
COOT	.0837	.1049	.2381	.0369	-.1505	.4788	.1961	.0557	-.0529	-.0761	-.1205	.0130	-.1646	.2360	-.1211	-.0435	.3502	-.1859	-.0865	.1794	-.0292	.3019
TDAB	.2788	-.0135	-.1279	-.2674	-.0090	.2393	-.1200	-.0578	-.0971	.0430	.0334	-.0592	-.1401	.2268	-.0901	-.0929	.3158	-.0972	-.1358	-.2086	.0715	.2803
TDIV	.2939	-.0528	.0028	-.3064	-.1091	.3374	-.1249	-.1799	-.2415	-.0036	-.0899	-.1552	-.3147	.3102	-.2333	-.2844	.5381	-.3042	-.3246	-.2453	-.2084	.0718
TBIRDS	.2846	-.0515	.0216	-.3065	-.0998	.3919	-.1182	-.1528	-.2472	-.0096	-.0894	-.1529	-.2574	.3051	-.1752	-.2356	.5373	-.2490	-.2602	-.1985	-.0909	.1437

Note: R values below .185 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL	- Mallard	SCAU	- Scaup sp.
PINT	- Northern Pintail	BAGO	- Barrow's Goldeneye
GWTE	- Green-winged Teal	BUFF	- Bufflehead
BWTE	- Blue-winged Teal	RUDU	- Ruddy Duck
CITE	- Cinnamon Teal	EAGR	- Eared Grebe
WIGE	- American Wigeon	HOGR	- Horned Grebe
SHOV	- Northern Shoveler	PBGR	- Pied-billed Grebe
GADW	- Gadwall	RNGR	- Red-necked Grebe
CAGO	- Canada Goose	COOT	- American Coot
REDH	- Redhead	TDAB	- Total Dabblers
RNDU	- Ring-necked Duck	TDIV	- Total Divers
CANV	- Canvasback	TBIRDS	- Total Birds

PLANT SPECIES:

1 - Aphanizomenon flos-aquae (L.) Relfs.	12 - Potamogeton pusillus L.
2 - Ceratophyllum demersum L.	13 - Potamogeton natans L.
3 - Chara sp.	14 - Potamogeton pectinatus L.
4 - Drepanocladus aduncus	15 - Potamogeton gramineus L.
5 - Eleocharis acicularis (L.) R. & S.	16 - Polygonum amphibium L.
6 - Filamentous algae	17 - Ruppia occidentalis L.
7 - Hippuris vulgaris L.	18 - Sagittaria cuneata Sheld.
8 - Lemna minor L.	19 - Sparganium sp. L.
9 - Myriophyllum exalbescens (Fern.) Jeps.	20 - Utricularia vulgaris L.
10 - Potamogeton zosteriformis Fern.	21 - Zanichellia palustris L.
11 - Potamogeton richardsonii (Benett) Rydb.	TAREA - Total Area Of Aquatic Plants

Table 22. Correlation matrix between total brood counts of 16 aquatic bird species and 21 aquatic plant species abundance values over 112 Riske Creek wetlands (Pearson correlation coefficients). All values were log transformed prior to analysis.

	AQUATIC PLANT SPECIES																					
BIRD SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TAREA
MALL	.1750	.0176	-.1045	-.1436	.0270	.1704	-.0520	-.0229	-.1358	.0367	.1131	-.1210	-.0601	.1107	-.0325	-.0284	.3764	-.0701	-.2051	-.2927	-.0602	.1077
PINT	.0235	-.0163	-.0577	-.1657	-.0150	.1244	.0398	.0393	.0185	-.0494	-.0100	.1549	-.0162	-.0502	.0275	.0546	.0492	.0513	.1103	-.0449	.0169	.0870
GWTE	.0050	-.2467	-.1770	-.0309	-.0431	-.0605	-.2251	-.1372	-.2704	-.0359	-.1525	-.2654	.1183	-.1093	.1431	-.0000	.1646	-.0305	-.0373	-.1024	.0676	-.1416
BWTE	.1621	.1055	-.2471	-.0149	.0299	-.0291	.0586	.1232	.1382	.0175	.2004	.1159	-.0020	-.0196	-.0066	.1149	.0218	.0680	.0157	-.2047	-.1015	.0809
CITE	-.0678	-.0838	-.0434	.0019	-.0408	-.0415	-.0628	.0897	-.1262	-.0222	-.0564	-.1278	.1538	-.0620	.3088	.1708	.0258	.0739	-.0479	.0899	-.0467	.0467
WIGE	.2224	-.0034	-.0634	-.1405	-.0392	.1745	-.0640	-.0554	-.1093	.0441	.0185	-.0428	-.1279	.3545	-.0435	-.0054	.2083	-.1010	-.1760	-.1683	-.0030	.2344
SHOV	.0324	-.0487	-.0033	-.1799	-.0538	.2049	-.0519	-.0495	.0279	.0816	-.1053	-.0646	-.1576	.2097	-.1276	-.1081	.1185	-.1526	-.1902	-.1647	.4258	.1431
GADW	-.0377	-.1618	-.1374	-.2599	-.1292	.2299	-.1987	-.1433	-.1692	-.0704	-.0017	-.1172	.0021	.2988	.0192	-.1715	.2031	-.1014	-.0479	-.1315	-.0918	.1080
CAGO	-.0505	-.0831	.0797	.0274	-.0748	.2260	-.0858	-.1355	-.1732	-.0408	-.1033	-.1487	-.0875	.1899	-.0589	-.1645	.3188	-.1148	-.0878	-.0221	-.0856	.0509
REDH	.1367	-.0667	-.0513	-.1043	-.1278	.4283	-.0602	-.1126	-.1781	-.0692	-.1753	-.1682	-.1484	.3118	-.1000	-.2397	.5259	-.1948	-.1491	-.0947	-.1452	.2672
RNDU	-.0536	-.1673	-.0341	.2129	-.0910	.0347	-.1099	-.1014	-.1381	-.0496	-.1257	-.0622	.0272	-.0366	.1384	-.1365	.2809	-.0703	-.0434	-.0418	-.1041	.0335
CANV	-.0846	-.0459	.0206	.0198	-.1140	.3087	.0126	-.0391	-.0911	-.0625	-.1584	-.0872	-.1342	.2913	-.0904	-.2098	.4618	-.1761	-.1340	.0645	-.1313	.1759
SCAU	.1896	-.1191	.0169	-.0399	-.1348	.3545	-.0716	-.1447	-.1685	-.0174	-.2093	-.0566	-.2222	.3414	-.1497	-.2566	.4238	-.2613	-.2232	-.0753	-.1735	.2049
BAGO	.1241	-.1655	-.0999	-.3315	.1218	.2170	-.2168	-.3163	-.2527	.1529	.1470	-.2439	-.1465	.1699	-.1198	-.0974	.3641	-.0410	-.2543	-.3702	.0609	.0625
BUFF	.0443	.0225	-.1064	-.1193	.0125	.0830	-.1650	-.1313	-.1991	.0259	.0526	-.2183	-.0505	-.0049	-.0689	-.1443	.4203	-.0659	-.1833	-.2499	-.2200	-.0124
RUDU	.0568	.0880	.0883	-.0480	-.1520	.3309	.1656	.0450	-.0091	-.0828	-.1685	.0501	-.1777	.2398	-.1198	-.1655	.2726	-.2333	-.1498	.1319	-.0814	.1898
TDAB	.1985	-.0293	-.2134	-.1748	-.0107	.1416	-.1361	-.0098	-.1070	.0883	.1187	-.0970	-.0235	.1281	.0191	-.0189	.2988	-.0322	-.1317	-.2951	.0360	.1542
TDIV	.1719	-.0150	-.0521	-.2676	-.0114	.3359	-.1179	-.2254	-.1854	.0658	.0412	-.1548	-.2618	.2713	-.2150	-.2635	.5536	-.2298	-.4053	-.3335	-.1273	.1273
TBIRDS	.2159	-.0345	-.1220	-.2788	-.0222	.2974	-.1597	-.1674	-.2189	.0486	.0698	-.1253	-.1899	.2360	-.1131	-.2095	.5126	-.1739	-.3292	-.3340	-.0835	.1351

Note: R values below .185 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL	- Mallard	RNDU	- Ring-necked Duck
PINT	- Northern Pintail	CANV	- Canvasback
GWTE	- Green-winged Teal	SCAU	- Scaup sp.
BWTE	- Blue-winged Teal	BAGO	- Barrow's Goldeneye
CITE	- Cinnamon Teal	BUFF	- Bufflehead
WIGE	- American Wigeon	RUDU	- Ruddy Duck
SHOV	- Northern Shoveler	TDAB	- Total Dabblers
GADW	- Gadwall	TDIV	- Total Divers
CAGO	- Canada Goose	TBIRDS	- Total Birds
REDH	- Redhead		

PLANT SPECIES:

1 - Aphanizomenon flos-aquae (L.) Relfs.	12 - Potamogeton pusillus L.
2 - Ceratophyllum demersum L.	13 - Potamogeton natans L.
3 - Chara sp.	14 - Potamogeton pectinatus L.
4 - Drepanocladus aduncus	15 - Potamogeton gramineus L.
5 - Eleocharis acicularis (L.) R. & S.	16 - Polygonum amphibium L.
6 - Filamentous algae	17 - Ruppia occidentalis L.
7 - Hippuris vulgaris L.	18 - Sagittaria cuneata Sheld.
8 - Lemna minor L.	19 - Sparganium sp. L.
9 - Myriophyllum exalbescens (Fern.) Jeps.	20 - Utricularia vulgaris L.
10 - Potamogeton zosteriformis Fern.	21 - Zanichellia palustris L.
11 - Potamogeton richardsonii (Benett) Rydb.	TAREA - Total Area Of Aquatic Plants

Table 23. Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) and dry weights of selected aquatic invertebrate taxa collected from activity traps over 7 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	STATION/REPETITION														
	SHAL1	SHAL2	SHAL3	SHAL4	SHALMEAN	DEEP1	DEEP2	DEEP3	DEEP4	DEEPMEAN	TOT1	TOT2	TOT3	TOT4	TOTMEAN
MALL	-.0659	.2601	-.0403	-.3471	.1131	-.2900	-.0019	-.2368	-.3081	-.2836	-.1720	.2070	-.0925	-.4078	-.0244
PINT	-.0188	.3062	-.2353	-.5183	.0369	-.0652	.1965	-.3908	-.6629	-.3178	-.0565	.2988	-.2764	-.6081	-.0810
GWTE	-.0972	.1389	-.2587	-.4628	-.0791	-.0979	.1488	-.3778	-.7098	-.3127	-.1142	.1628	-.2922	-.5607	-.1571
BWTE	.4657	.6495	.4532	.1574	.6198	.3951	.4734	.3055	.0997	.2750	.4367	.6110	.4197	.0748	.5173
CITE	.7875	.6523	.9490	.8621	.8975	.7091	.6888	.8831	.7127	.8301	.7902	.6440	.9375	.8005	.8937
WIGE	.1605	.4025	-.1142	-.3587	.1501	.0600	.3582	-.2544	-.5912	-.1193	.1193	.4240	-.1513	-.4379	.0653
SHOV	-.1989	.1673	-.1213	-.4032	.0169	-.5537	-.2774	-.3051	-.1645	-.3911	-.3586	.0488	-.1695	-.3782	-.1321
GADW	.3159	.6057	.2428	-.0589	.4628	-.0599	.2585	.0107	-.1541	.0557	.1791	.5379	.1828	-.1185	.3278
CAGO	-.4489	-.4988	-.5674	-.4147	-.5902	-.2026	-.3426	-.3751	-.0698	-.3622	-.3722	-.4822	-.5163	-.2965	-.5179
REDH	.3128	.4249	.2916	.0424	.3910	.3076	.4533	.1873	-.1640	.1760	.3068	.4560	.2668	-.0507	.3322
RNDU	.4183	.6051	.4145	.0588	.5353	.0353	.4004	.2711	.1153	.2531	.2766	.5816	.3814	.0878	.4530
CANV	.2776	.3814	.4008	.1759	.3979	-.2588	.0891	.2871	.3581	.2352	.0869	.3260	.3734	.2771	.3461
SCAU	.0706	-.0671	.4552	.5212	.2367	.2181	-.0633	.4498	.4520	.2526	.1254	-.0881	.4545	.4441	.2421
BAGO	.7447	.8056	.7316	.4868	.8606	.6613	.6988	.6854	.3485	.6062	.7386	.7882	.7858	.4026	.7952
BUFF	-.3288	-.1544	-.0888	-.0792	-.0788	-.5886	-.5074	-.0987	.1752	-.2962	-.4122	-.2725	-.0275	-.0615	-.1682
RUDU	-.2688	-.2068	.1881	.0246	-.0665	-.4148	-.3725	.0377	.1481	-.1733	-.3431	-.2598	.0825	.0333	-.1123
EAGR	-.1232	.1415	.0513	-.0906	.1095	-.5368	-.3738	-.1436	.0881	-.2388	-.2863	-.0837	-.0817	-.0776	-.0223
HOGR	-.9878	-.8749	-.6554	-.4418	-.8258	-.6233	-.8251	-.6588	-.5722	-.7845	-.8363	-.8885	-.6634	-.5416	-.8398
PBGR															
RNGR	-.8111	-.7667	-.5887	-.3275	-.6791	-.6866	-.8264	-.4952	-.2844	-.6754	-.7697	-.8181	-.5861	-.3819	-.7845
COOT	-.1951	-.2338	.1848	.1521	-.0959	-.5889	-.4348	.0687	.2951	-.0443	-.3348	-.2846	.0928	.2465	-.0922
TDABS	.2177	.4885	.1693	-.1398	.3648	.0784	.3858	-.0297	-.3257	-.0253	.1563	.4617	.1188	-.2485	.2377
TDIVS	.1893	.2768	.4919	.3417	.4483	.1848	.8462	.3551	.3189	.1846	.1521	.2855	.4579	.2591	.3545
TBIRDS	.1585	.3357	.3715	.1535	.4836	.0555	.1887	.1866	.8249	.8611	.1182	.2749	.3238	.8373	.2881

Notes: R values below .755 are not significant at the 0.05 level. A blank row indicates the absence of a species.

Legend:

BIRD SPECIES:

MALL	- Mallard	SCAU	- Scaup sp.
PINT	- Northern Pintail	BAGO	- Barrow's Goldeneye
GWTE	- Green-winged Teal	BUFF	- Bufflehead
BWTE	- Blue-winged Teal	RUDU	- Ruddy Duck
CITE	- Cinnamon Teal	EAGR	- Eared Grebe
WIGE	- American Wigeon	HOGR	- Horned Grebe
SHOV	- Northern Shoveler	PBGR	- Pied-billed Grebe
GADW	- Gadwall	RNGR	- Red-necked Grebe
CAGO	- Canada Goose	COOT	- American Coot
REDH	- Redhead	TDABS	- Total Dabblers
RNDU	- Ring-necked Duck	TDIVS	- Total Divers
CANV	- Canvasback	TBIRDS	- Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations
DEEP - 1.0 m Stations
TOT - SHAL plus DEEP
1,2,3,4 - Repetition (ie. different survey dates)
MEAN - Average of Repetitions 1,2,3,4

Table 24. Correlation matrix between total brood counts of 16 aquatic bird species and dry weights of selected aquatic invertebrate taxa collected from activity traps over 7 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	STATION/REPETITION														
	SHAL1	SHAL2	SHAL3	SHAL4	SHALMEAN	DEEP1	DEEP2	DEEP3	DEEP4	DEEPMEAN	TOT1	TOT2	TOT3	TOT4	TOTMEAN
MALL	-.4303	-.1013	-.1101	-.2324	-.1541	-.5639	-.5170	-.2983	-.2424	-.4702	-.5100	-.2022	-.1699	-.3174	-.2839
PINT															
GWTE	-.5800	-.4329	-.7076	-.6540	-.6058	-.1946	-.3469	-.6753	-.6588	-.6673	-.4727	-.4321	-.7023	-.7283	-.6302
BWTE	-.1894	-.2117	.2176	.2247	.0158	-.1089	-.2358	.1421	.0356	-.0637	-.1723	-.2275	.1947	.1083	-.0190
CITE															
WIGE	-.0212	.2562	-.2407	-.4101	.0098	-.1592	.0900	-.4148	-.6395	-.2913	-.0778	.2344	-.2095	-.5020	-.0972
SHOV	.2609	.1383	.5190	.4668	.3289	-.1371	.0535	.5007	.5554	.4076	.1321	.1344	.5156	.5658	.3599
GADW	.1960	.0318	.3298	.3224	.1697	.0557	.2203	.3290	.0683	.3123	.1624	.1153	.3281	.3147	.2257
CAGO															
REDH	.1380	.3202	-.0509	-.1278	.1749	.1876	.2044	-.2033	-.4475	-.0866	.1604	.2978	-.0930	-.2802	.0843
RNDU															
CANV															
SCAU	-.0445	-.0060	.3752	.3937	.2338	-.1204	-.3167	.2437	.3710	.0415	-.0764	-.1160	.3390	.3058	.1555
BAGO	.1282	.0586	.4981	.4905	.3183	.0498	-.1140	.4769	.6606	.2767	.0993	-.0180	.4953	.5047	.3037
BUFF	-.4907	-.2423	-.2319	-.3677	-.2653	-.6657	-.5333	-.3661	-.2535	-.5336	-.5900	-.3282	-.2707	-.3880	-.3743
RUDU	.2618	.1181	.5221	.6403	.3612	.0266	-.0634	.4667	.5812	.4056	.2039	.0638	.5065	.6405	.3710
TDABS	-.4469	-.1890	-.2494	-.3781	-.2402	-.5586	-.4018	-.4374	-.5628	-.5438	-.5163	-.2402	-.3050	-.4941	-.3611
TDIVS	-.2159	-.0893	.1692	.1031	.0589	-.3475	-.4151	.0467	.2202	-.1699	-.2837	-.1993	.1358	.0653	-.0326
TBIRDS	-.3882	-.1944	-.0167	-.0980	-.1032	-.5001	-.4964	-.1890	-.1502	-.3896	-.4555	-.2887	-.0665	-.1950	-.2195

Notes: R values below .755 are not significant at the 0.05 level. A blank row indicates the absence of a species.

Legend:

BIRD SPECIES:

MALL - Mallard
PINT - Northern Pintail
GWTE - Green-winged Teal
BWTE - Blue-winged Teal
CITE - Cinnamon Teal
WIGE - American Wigeon
SHOV - Northern Shoveler
GADW - Gadwall
CAGO - Canada Goose
REDH - Redhead
RNDU - Ring-necked Duck
CANV - Canvasback
SCAU - Scaup sp.
BAGO - Barrow's Goldeneye
BUFF - Bufflehead
RUDU - Ruddy Duck
TDABS - Total Dabblers
TDIVS - Total Divers
TBIRDS - Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations
DEEP - 1.0 m Stations
TOT - SHAL plus DEEP
1,2,3,4 - Repetition (ie. different survey dates)
MEAN - Average of Repetitions 1,2,3,4

Table 25. Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) and dry weights of Chironomidae collected from bottom cores over 43 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	STATION/REPETITION								
	SHAL1	SHAL2	SHALMEAN	DEEP1	DEEP2	DEEPMEAN	TOT1	TOT2	TOTMEAN
MALL	.2842	.1968	.2574	.2593	.2643	.2622	.2727	.2647	.2702
PINT	.3222	.2701	.2918	.1449	.1964	.1433	.2833	.2835	.2722
GWTE	.1854	.2341	.2319	.1308	.1318	.1152	.1726	.2239	.2052
BWTE	.2773	.2243	.2673	.3500	.1931	.2401	.3160	.2172	.2800
CITE	.2734	.1847	.2237	.1627	.1384	.1342	.2439	.1617	.2016
WIGE	.3981	.3625	.4054	.3298	.2282	.2423	.3961	.3305	.3681
SHOV	.2713	.3267	.2970	.1278	.2684	.2284	.2271	.3325	.2799
GADW	.4952	.4887	.5146	.3145	.4071	.3760	.4433	.4834	.4762
CAGO	-.3159	-.2001	-.2751	-.3467	-.1242	-.2003	-.3504	-.1622	-.2597
REDH	.3374	.3741	.3743	.2566	.2565	.2491	.3185	.3281	.3340
RNDU	.1663	.2092	.1629	.1281	.2313	.1901	.1275	.2381	.1755
CANV	.2591	.2836	.2421	.2587	.3093	.2935	.2594	.3029	.2711
SCAU	.2661	.3700	.3448	.3419	.3908	.4248	.3310	.4199	.4090
BAGO	.0969	.1189	.1567	.1548	.2278	.1909	.1261	.2029	.1793
BUFF	.0810	.0530	.0822	.0643	.1669	.1466	.0136	.1134	.0881
RUDU	.2502	.3112	.2712	.1616	.2157	.1954	.2076	.2614	.2373
EAGR	.0689	.1401	.0889	-.0010	.0231	.0114	.0231	.0810	.0475
HOGR	-.1830	-.2436	-.1933	-.1950	-.0793	-.1276	-.2017	-.1457	-.1726
PBGR	-.1092	-.0629	-.1476	-.1007	-.0205	-.0781	-.2150	-.0480	-.1252
RNGR	-.1656	-.1012	-.1900	-.1522	-.0083	-.0527	-.1925	-.0913	-.1396
COOT	.0595	.1168	.0740	-.0414	-.0341	-.0349	.0037	.0326	.0132
TDABS	.3787	.3303	.3798	.3017	.2583	.2676	.3687	.3327	.3620
TDIVS	.1872	.2704	.2756	.2380	.3201	.3072	.2182	.3300	.2971
TBIRDS	.1993	.2674	.2715	.1705	.2467	.2190	.1952	.2881	.2587

Note: R values below .301 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL	- Mallard	SCAU	- Scaup sp.
PINT	- Northern Pintail	BAGO	- Barrow's Goldeneye
GWTE	- Green-winged Teal	BUFF	- Bufflehead
BWTE	- Blue-winged Teal	RUDU	- Ruddy Duck
CITE	- Cinnamon Teal	EAGR	- Eared Grebe
WIGE	- American Wigeon	HOGR	- Horned Grebe
SHOV	- Northern Shoveler	PBGR	- Pied-billed Grebe
GADW	- Gadwall	RNGR	- Red-necked Grebe
CAGO	- Canada Goose	COOT	- American Coot
REDH	- Redhead	TDABS	- Total Dabblers
RNDU	- Ring-necked Duck	TDIVS	- Total Divers
CANV	- Canvasback	TBIRDS	- Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations
DEEP - 1.0 m Stations
TOT - SHAL plus DEEP
1,2 - Repetition
MEAN - Average of Repetitions 1,2

Table 26. Correlation matrix between total brood counts of 16 aquatic bird species and dry weights of Chironomidae collected from bottom cores over 43 Riske Creek wetlands (Pearson correlation coefficients). Values were log transformed prior to analysis.

	STATION/REPETITION								
	SHAL1	SHAL2	SHALMEAN	DEEP1	DEEP2	DEEPMEAN	TOT1	TOT2	TOTMEAN
MALL	-.0188	.0027	.0217	.0557	.0820	.0786	-.0046	.0347	.0276
PIBT	.2064	.1264	.1468	.1098	.0478	.0623	.2169	.1391	.1641
GWTE	.0386	.1115	.1406	-.0167	.0631	.0456	.0525	.1518	.1314
BWTE	.0602	-.1042	.0291	.1033	.0116	.0380	.0474	-.0524	.0154
CITE	.0410	.0774	.0532	.1183	.0047	.0583	.0738	.0423	.0498
WIGE	.3001	.1405	.2207	.2768	.2006	.1959	.2927	.1939	.2199
SHOV	.3012	.1304	.2614	.1253	.1308	.1143	.2553	.1754	.2228
GADW	.0722	.1475	.1071	-.0047	.0601	.0201	.0317	.1133	.0789
CAGO	-.1997	-.1359	-.1782	-.1220	.0254	-.0213	-.1876	-.0339	-.1070
REDH	.1411	.1888	.1529	.0677	.0681	.0673	.1077	.1369	.1186
RHDU	-.2335	-.1476	-.2259	-.1178	-.0105	-.0352	-.2025	-.0627	-.1399
CANV	-.0848	.0246	-.0635	-.0123	-.0128	-.0117	-.0795	.0110	-.0536
SCAU	.3298	.3312	.3541	.2397	.3220	.3117	.2881	.3551	.3406
BAGO	.1239	.0756	.1138	.2032	.1334	.1747	.1480	.1197	.1326
BUFF	.0040	-.0290	.0301	.1239	.1153	.1172	.0362	.0330	.0365
RUDU	.1322	.1603	.1325	.0762	.0035	.0575	.1019	.0707	.0857
TDABS	.1834	.0881	.1791	.1631	.1257	.1238	.1863	.1394	.1736
TDIVS	.2016	.1612	.2157	.2362	.2402	.2672	.2022	.2133	.2154
TBIRDS	.2269	.1778	.2462	.2338	.2309	.2332	.2252	.2293	.2347

Note: R values below .301 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL - Mallard
PIBT - Northern Pintail
GWTE - Green-winged Teal
BWTE - Blue-winged Teal
CITE - Cinnamon Teal
WIGE - American Wigeon
SHOV - Northern Shoveler
GADW - Gadwall
CAGO - Canada Goose
REDH - Redhead
RHDU - Ring-necked Duck
CANV - Canvasback
SCAU - Scaup sp.
BAGO - Barrow's Goldeneye
BUFF - Bufflehead
RUDU - Ruddy Duck
TDABS - Total Dabblers
TDIVS - Total Divers
TBIRDS- Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations
DEEP - 1.0 m Stations
TOT - SHAL plus DEEP
1,2 - Repetition
MEAN - Average of Repetitions 1,2

Table 27. Correlation matrix between mean adult counts of 21 aquatic bird species (potential breeders only) and numbers and dry weights of aquatic invertebrate taxa collected from sweep net samples over 39 Riske Creek wetlands, 1984 and 1985 (Pearson correlation coefficients. Values were log transformed prior to analysis.

	STATION/REPETITION											
	NUM845TOT	NUM845SEL	DW845SEL	SHAL1	SHAL2	SHALMEAN	DEEP1	DEEP2	DEEPMEAN	OW1	OW2	OWMEAN
MALL	.0602	.1139	.1389	.2066	.2018	.2039	.2294	.2192	.2297	.0200	.0200	.0301
PINT	.1026	.0520	.0571	.1253	.2406	.1946	.0125	.1209	.0631	-.2178	-.1014	-.1571
GWTE	.1094	.0298	.0023	.1958	.1696	.1796	.1687	.1140	.1394	-.0542	.0063	.0061
BWTE	.1862	.2387	.2887	.2584	.4605	.4203	.2871	.4393	.4026	-.0297	.0406	.0732
CITE	.0533	.1140	.1923	.1220	.2706	.2275	.1205	.3224	.2278	-.0054	.1427	.0925
WIGE	.1452	.3004	.2432	.2236	.3768	.3892	.1713	.3066	.3097	.0314	.1455	.1473
SHOV	.4280	-.2298	-.1298	-.1003	-.0224	-.0550	-.2969	-.1485	-.2363	-.4031	-.3118	-.3852
GADW	.5187	.1357	.1469	.1591	.2280	.2233	-.1019	.1518	.0709	-.1062	-.0242	-.0568
CAGO	-.0073	-.1055	-.2264	-.1204	-.2334	-.2059	-.1485	-.1334	-.1558	-.0301	.0212	-.0561
REDH	.2098	.3441	.2425	.2328	.2373	.2767	.1592	.2951	.2618	.1208	.0511	.1708
RNDU	.2479	.1355	.1034	.1316	.1559	.2061	.1105	.2552	.2227	.0116	.0487	.0360
CANV	.0815	.2227	.1571	.0777	.1747	.1651	.0743	.2646	.2124	.0858	.3084	.2362
SCAU	.4201	-.0094	.1400	-.0067	.1092	.1421	-.1024	.0816	-.0122	-.2625	-.1387	-.2198
BAGO	-.0162	.0865	.0855	.1027	.1369	.1883	.1471	.1612	.1507	-.0299	.0992	.0477
BUFF	.1331	-.1915	-.1824	-.1558	-.0964	-.0831	-.1655	-.0439	-.1022	-.2253	-.0551	-.1403
RUDU	.3615	.0641	.0390	-.0349	.1506	.0881	-.1172	.1786	.0422	-.1623	.0746	-.0518
EAGR	.4972	-.1246	-.1185	-.2547	-.0260	-.1003	-.4467	-.1007	-.2289	-.3531	-.1481	-.2642
HOGR	-.3278	-.2696	-.2855	-.1120	-.2618	-.2230	-.0003	-.2134	-.1624	-.1451	-.0675	-.1604
PBGR	-.0784	.0444	.0133	.0883	-.0433	-.0096	.1111	.0970	.0771	.1759	.2113	.1770
RNGR	-.1982	-.0774	.0327	.0982	.0546	.0680	.1086	.1125	.1209	-.0470	-.0802	-.1076
COOT	.2528	.0146	.0159	.0373	.0741	.0422	-.0881	.1777	.0831	.0847	.2029	.1285
TDABS	.2740	.1302	.1830	.2230	.3515	.3469	.1578	.2690	.2469	-.1078	-.0170	-.0225
TDIVS	.2069	.0125	.0316	.0571	.0942	.1135	-.0129	.1196	.0477	-.1554	.0438	-.0553
TBIRDS	.2910	.0190	.0224	.0679	.1344	.1360	-.0188	.1555	.0721	-.1588	.0442	-.0513

Note: R values below .316 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL	- Mallard	SCAU	- Scaup sp.
PINT	- Northern Pintail	BAGO	- Barrow's Goldeneye
GWTE	- Green-winged Teal	BUFF	- Bufflehead
BWTE	- Blue-winged Teal	RUDU	- Ruddy Duck
CITE	- Cinnamon Teal	EAGR	- Eared Grebe
WIGE	- American Wigeon	HOGR	- Horned Grebe
SHOV	- Northern Shoveler	PBGR	- Pied-billed Grebe
GADW	- Gadwall	RNGR	- Red-necked Grebe
CAGO	- Canada Goose	COOT	- American Coot
REDH	- Redhead	TDABS	- Total Dabblers
RNDU	- Ring-necked Duck	TDIVS	- Total Divers
CANV	- Canvasback	TBIRDS	- Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations, Dry Weights Of Selected Taxa 1985
DEEP - 1.0 m Stations, Dry Weights Of Selected Taxa 1985
OW - Open Water Stations, Dry Weights Of Selected Taxa 1985
1,2 - Repetition (ie. different survey dates)
MEAN - Average of Repetitions 1,2
NUM845TOT - Total Number Of Invertebrates Averaged Over 1984 and 1985
NUM845SEL - Total Number Of Selected Invertebrates Averaged Over 1984 and 1985
DW845SEL - Dry Weights Of Selected Invertebrates Averaged Over 1984 and 1985

Table 20. Correlation matrix between total brood counts of 16 aquatic bird species and numbers and dry weights of aquatic invertebrate taxa collected from sweep net samples over 39 Riske Creek wetlands, 1984 and 1985 (Pearson correlation coefficients). Values were log transformed prior to analysis.

	STATION/REPETITION											
	HUN845TOT	HUN845SEL	DW845SEL	SHAL1	SHAL2	SHALMEAN	DEEP1	DEEP2	DEEPMEAN	OW1	OW2	OWMEAN
MALL	-.2120	-.0523	-.1042	.1025	-.0426	.0160	.1715	.0748	.0877	-.2059	.0313	.0287
PINT	.1549	.0634	.1488	.0883	.1984	.1260	-.0607	-.0271	-.0609	-.0503	-.2370	-.2980
GWTE	.0599	-.2068	-.1699	.0650	-.0553	.0103	.0346	-.1296	-.0776	-.1701	-.1060	-.1478
BWTE	-.0778	.0396	.0623	.0691	.0244	.0883	-.0025	-.0542	-.0227	-.2485	-.2474	-.2832
CITE	-.0760	.1509	.1346	.1780	.1124	.1370	.2536	.1879	.2155	-.0259	.2578	.2652
WIGE	.0172	.2102	.2072	.3305	.3329	.3458	.2988	.2797	.2975	-.2207	.3505	.2844
SHOV	.2099	.1222	.1757	.1360	.3345	.3057	.0119	.2032	.1616	-.1020	-.1257	-.1015
GADW	.3479	.0347	-.0459	-.1643	.0225	-.0104	-.2495	-.1137	-.1201	-.1032	-.2444	-.2927
CAGO	-.1042	-.0556	-.0474	.1320	-.1365	-.0268	.0971	-.0308	.0148	.1112	.1003	.0624
REDH	.2263	.1899	.1621	.1553	.1667	.1774	.1358	.2689	.2265	.2030	.2327	.2343
RHDU	-.2274	-.0421	.0064	.1231	-.1114	-.0127	.2143	.0319	.1039	.2722	.0059	.0871
CANV	-.0712	-.0442	.0188	.1258	.0382	.0458	.1552	.1408	.1293	.1435	.2208	.1502
SCAU	.2272	.0517	.2079	.3788	.3284	.3666	.2488	.3399	.2851	-.1612	.0369	-.0230
BAGO	-.0888	-.0915	.0844	.0019	.0488	.0651	-.0215	-.0894	-.0869	-.0160	-.2162	-.2091
BUFF	-.1025	.0111	-.1612	-.0384	-.1372	-.0968	.0525	.0882	.0830	.0494	.1739	.1351
RUDU	.1012	.0196	.0739	.1263	.1158	.0949	.1070	.2187	.1647	.1056	.3049	.2250
TDABS	-.0369	.1137	.0844	.1924	.1739	.2179	.1781	.1255	.1581	-.4353	-.0154	-.0638
TDIVS	.0203	-.0971	-.0641	.0779	.0366	.0697	.0468	.1133	.0579	.0298	.0175	-.0510
TBIRDS	.0171	-.0405	-.0216	.1229	.0942	.1288	.1088	.1043	.0820	-.0934	-.0048	-.0698

Note: R values below .316 are not significant at the 0.05 level.

Legend:

BIRD SPECIES:

MALL - Mallard
PINT - Northern Pintail
GWTE - Green-winged Teal
BWTE - Blue-winged Teal
CITE - Cinnamon Teal
WIGE - American Wigeon
SHOV - Northern Shoveler
GADW - Gadwall
CAGO - Canada Goose
REDH - Redhead
RHDU - Ring-necked Duck
CANV - Canvasback
SCAU - Scaup sp.
BAGO - Barrow's Goldeneye
BUFF - Bufflehead
RUDU - Ruddy Duck
TDABS - Total Dabblers
TDIVS - Total Divers
TBIRDS - Total Birds

STATION/REPETITION:

SHAL - 0.5 m Stations, Dry Weights Of Selected Taxa 1985
DEEP - 1.0 m Stations, Dry Weights Of Selected Taxa 1985
OW - Open Water Stations, Dry Weights Of Selected Taxa 1985
1,2 - Repetition (ie. different survey dates)
MEAN - Average of Repetitions 1,2
HUN845TOT - Total Number Of Invertebrates Averaged Over 1984 and 1985
HUN845SEL - Total Number Of Selected Invertebrates Averaged Over 1984 and 1985
DW845SEL - Dry Weights Of Selected Invertebrates Averaged Over 1984 and 1985